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INTERACTIVE EFFECTS OF DESUPERHEATING AND
LIQUID PRESSURE AMPLIFICATION

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ABSTRACT

This paper explores the interactive effects of installing desuperheating and a liquid pressure amplification together in a refrigeration or air conditioning system. Only "Freon" systems using reciprocating compressors are addressed in this paper since these are the only systems to which liquid pressure amplification can be applied.

The major conclusion derived from this study is that there are many applications where these two technologies can be installed successfully and economically together on the same machine. In general, installations where the cooling load is large throughout the year are the most desirable. Examples of this would be a thermally heavy commercial building or a process cooling load. In addition, the savings and simple payback tend to improve as the machine tonnage increases. The refrigerant used also has an impact on the economics of the installation. Of the three refrigerants considered (R-12, R-22, and R-502), the savings and payback were best for R-502.

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INTRODUCTION

Over the last year and a half, members of the Refrigeration Tune Up (RTU) Program at Oklahoma State University have completed 40 audits. During this time, two of the major recommendations made in the RTU program have been desuperheating and installation of the liquid pressure amplifier (Hy-Save)¹. Although the calculation procedures for these two individual recommendations are fairly well developed (though desuperheating still needs some work), the interaction between these two technologies has not been sufficiently explored.

Since desuperheating has the effect of reducing the condensing pressure, a characteristic that the Hy-Save can take advantage of, it would be desirable to quantify the effect of installing the two together. This advantage, however, must be balanced by what will be shown to be the loss of recoverable heat due to the low condensing pressures available using the Hy-Save.

Therefore, the aim of this report is to predict the interaction of these two technologies and the associated effect that this would have on their economic feasibility.

It should be noted that there is no experimental data available to quantify the interaction of these technologies and that little theoretical work has been done in this area either. Therefore, this project will consist mainly of theoretical work with the need

¹Both technologies will be explained shortly

to make some underlying assumptions that may or may not prove to be totally valid upon further work by other researchers. The purpose of this project, however, will be to provide some initial projections about the interaction of the Hy-Save and desuperheating under specific conditions, as well as to define the additional questions and issues that need to be addressed in the future. Also, this work will provide the reader with some idea of whether or not these two technologies should be recommended simultaneously.

Further, it should be noted that this project will, necessarily address only "Freon" systems with reciprocating compressors, and will not attempt to make any conclusions about ammonia systems. The reason for this restriction is that the Hy-Save technology can only be applied to reciprocating compressors that use a "Freon" refrigerant.

In the report that follows, a short discussion of how the desuperheating and Hy-Save technologies operate independently will be given. Following this discussion will be a section which outlines the predicted interactions when the two technologies are applied simultaneously. The next section presents a discussion of the calculation procedures used in this report and includes step by step examples. After calculation methods, the results are presented along with a sensitivity analyses for certain variables (i.e. load profile, tonnage, refrigerant used). Finally, recommendations and suggestions for further research are discussed followed by the conclusions.

BACKGROUND

Liquid Pressure Amplifier Operation

For many years, it has been necessary to maintain high head pressure in refrigeration cycles in order to prevent flash gas from forming in the liquid line and to insure proper oil return to the compressor. If pressure was allowed to fall below a certain level, the flash gas would take up a relatively large volume in the liquid line and would cause flow problems in the thermal expansion valve (TXV). Therefore, a minimum acceptable head pressure had to be established and was maintained by cycling off condensing fans. Figures 1 and 2 show a basic refrigeration circuit with its associated Mollier diagram (Pressure vs. Enthalpy).

From Figure 2, it can be shown that it is desirable to keep the evaporating and condensing pressures as close together as possible. As these two lines come closer together, the work that is required to raise the pressure of the suction gas is reduced. Therefore, for a given evaporating temperature and pressure, it is desirable to keep the condensing pressure as low as possible. Obviously, the condensing pressure is controlled by the ambient wet or dry bulb temperatures. The condensing pressure generally floats 15 to 20 °F above the ambient dry bulb for air cooled systems and 10 to 20 °F above the wet bulb temperature for evaporative condensers.

For the reasons outlined above, it becomes obvious that it is advantageous to operate refrigeration and air conditioning units

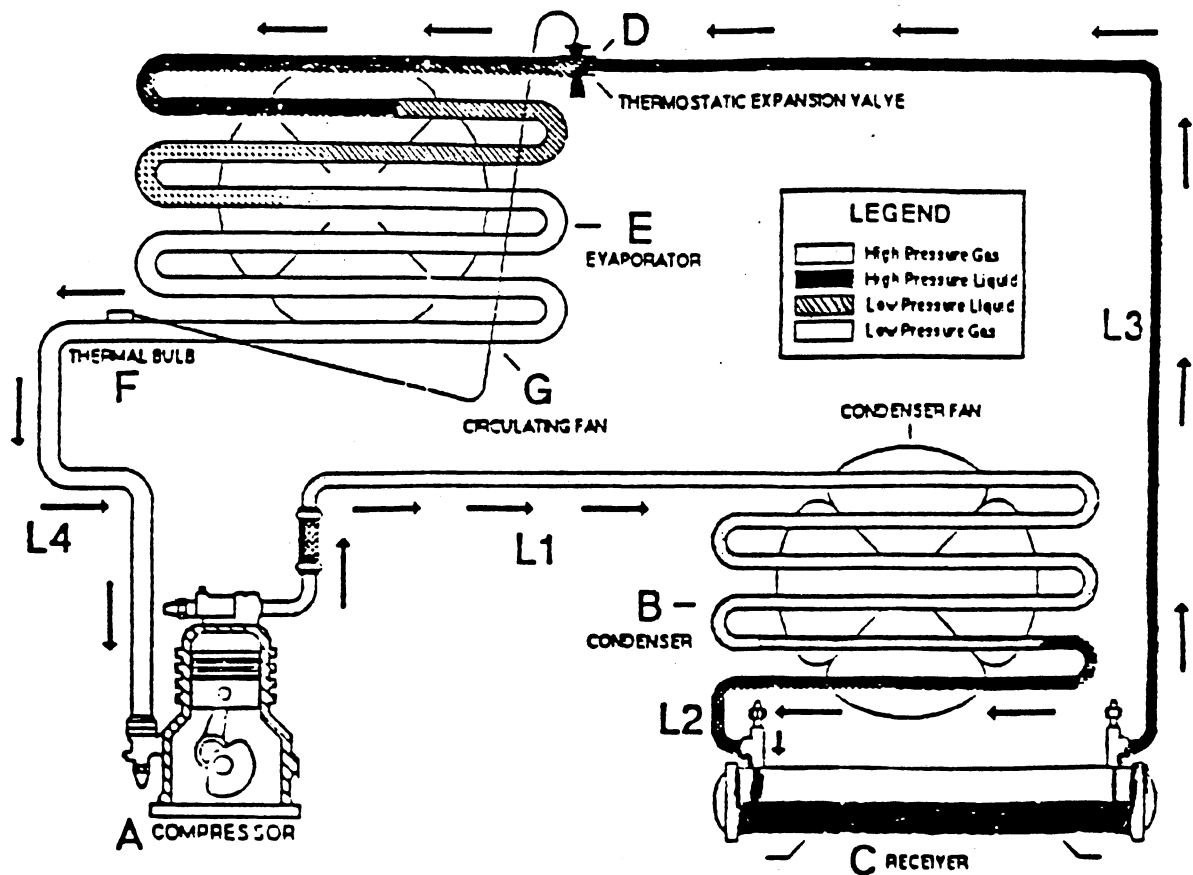


FIGURE 1 - BASIC REFRIGERATION CIRCUIT

Source: Hy-Save vendor literature

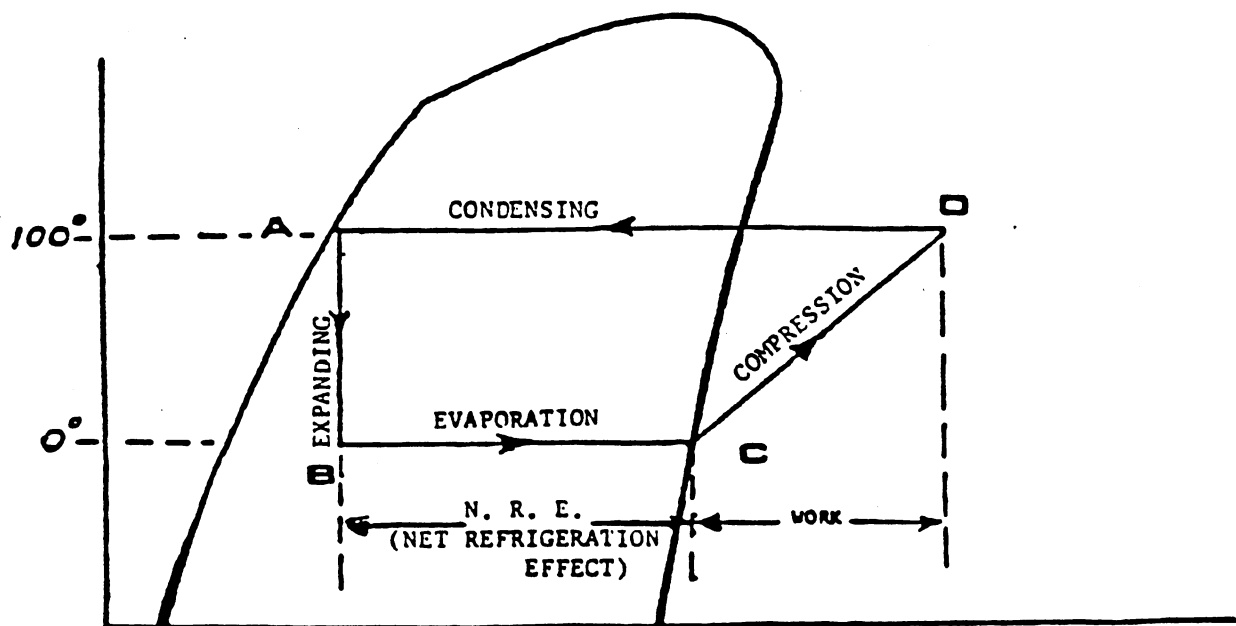


FIGURE 2 Enthalpy (Btu/lb)

Source: Hy-Save vendor literature

while ambient temperatures are low. As mentioned above, however, as ambient temperatures drop in traditional systems, the minimum condensing pressure will be reached and must be artificially maintained. These artificially high condensing pressures have traditionally been considered a necessary evil even though they are an obvious waste of energy.

A recent technological development, the Liquid Pressure Amplifier (Hy-Save) pump, has now made it possible to reduce the condensing pressure below traditional levels during low ambient temperatures without the problems of flash gas in the liquid line or poor oil return. Condensing temperatures as low as 60°F are possible. The Hy-Save is simply a small liquid refrigerant pump which is installed between the receiver and the TXV (see figure 1 for location). The pump has a magnetic coupling which eliminates the need for seals, thus reducing the chance of a refrigerant leak (an important quality with the rising cost of CFC's). The Hy-Save pumps come in 1/25 hp and 1/5 hp sizes. The 1/25 hp size applies to 7.5 ton units and below while the 1/5 hp pump is used on 7.5 to 20 ton units. For units above 20 tons, multiple Hy-Save pumps are used in parallel.

As the condensing pressure drops below a set value (usually the previous low pressure limit) the Hy-Save pump is activated and adds about 10 psia to the liquid refrigerant. This added pressure inhibits formation of the flash gases and also insures proper oil return to the compressor. Therefore, with the Hy-Save pump, the

problems of low ambient operation are avoided by pumping a liquid rather than compressing a gas which is much more expensive.

One additional benefit of the Hy-Save technology is that the net refrigeration effect for each pound of refrigerant is increased as the condensing pressure is reduced. Compare the net refrigeration effect for a unit with and without the Hy- Save in Figures 3 and 4.

In general, the savings that can be achieved using the Hy- Save pump are dependant upon the hours of operation during low ambient temperatures as well as the cooling load on the compressor during these times. For example, the savings for an air conditioning unit that operates from April through September will not be as great as for a refrigeration unit which is used for cold storage for the entire year.

The procedure used for calculating the savings for the Hy- Save in this report is based on a spreadsheet obtained from Oregon State University's Energy Analysis and Diagnostic Center. This procedure basically assigns 1% savings for every 1°F reduction in condensing temperature. Experience with the RTU program has shown that, for Oklahoma, the economics tend to favor units that are 10 tons or larger which run most of the year. Some 7.5 tons units, however can result in under 3 year paybacks if they are very heavily loaded all year long.

The installed costs for the Hy-Save pumps are \$1,500 to \$1,800 for the 1/5 hp and \$1,200 to \$1,500 for the 1/25 hp.

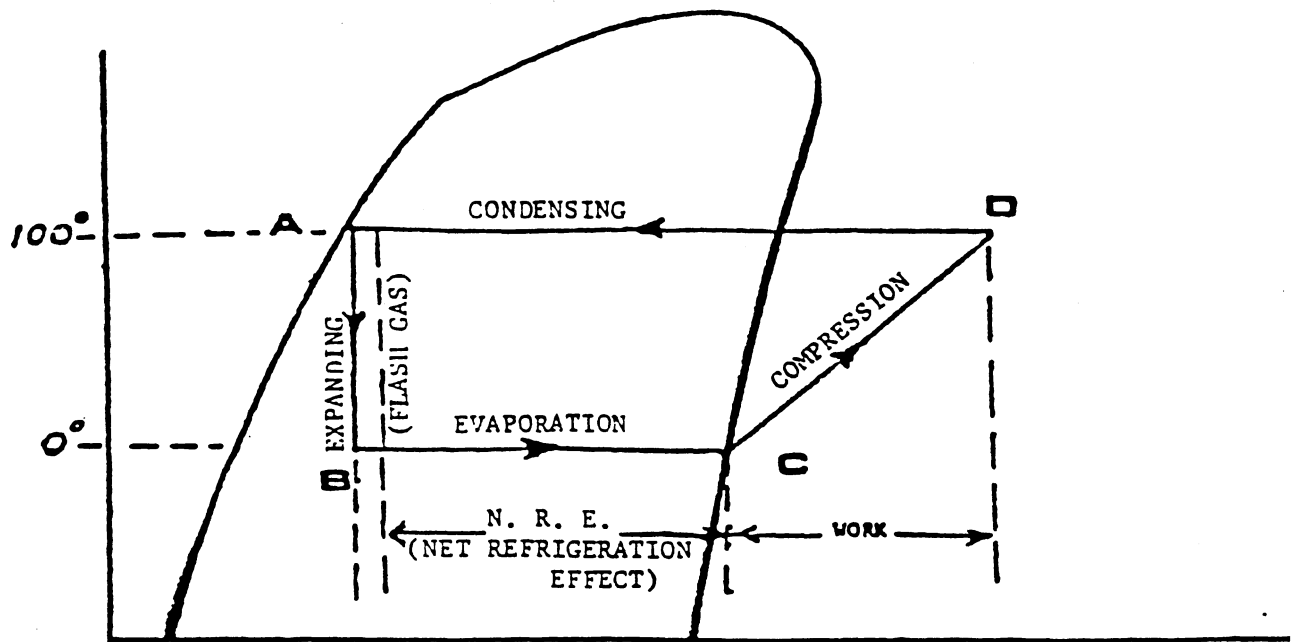
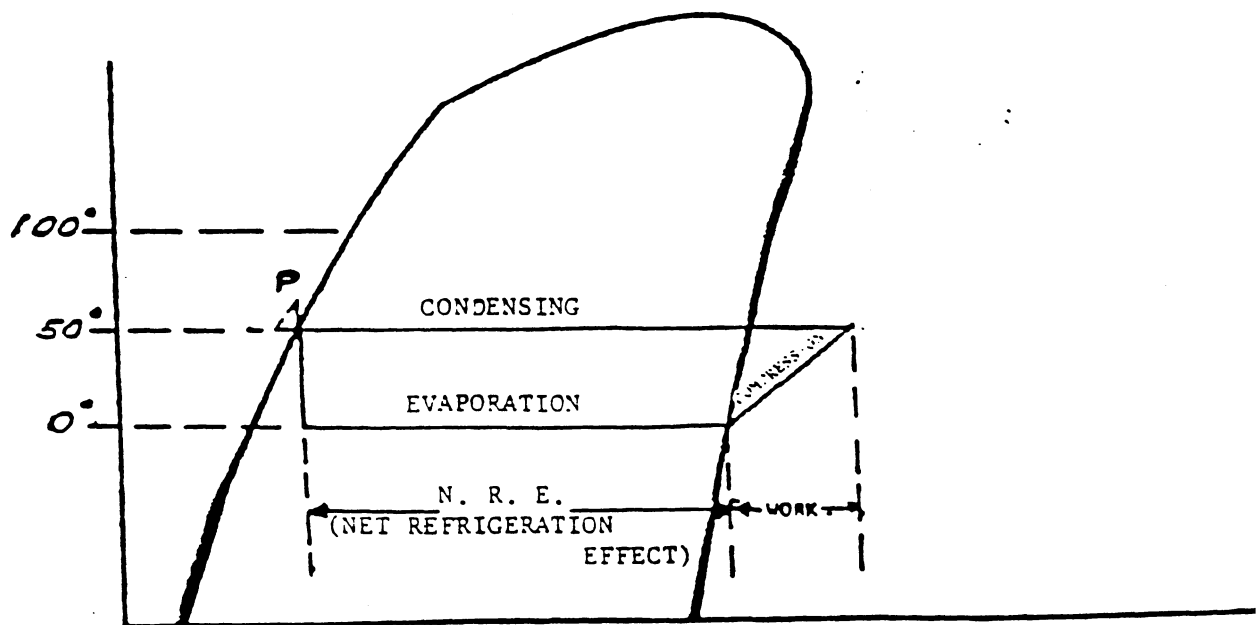


FIGURE 3 Enthalpy (Btu/lb)

Source: Hy-Save vendor literature

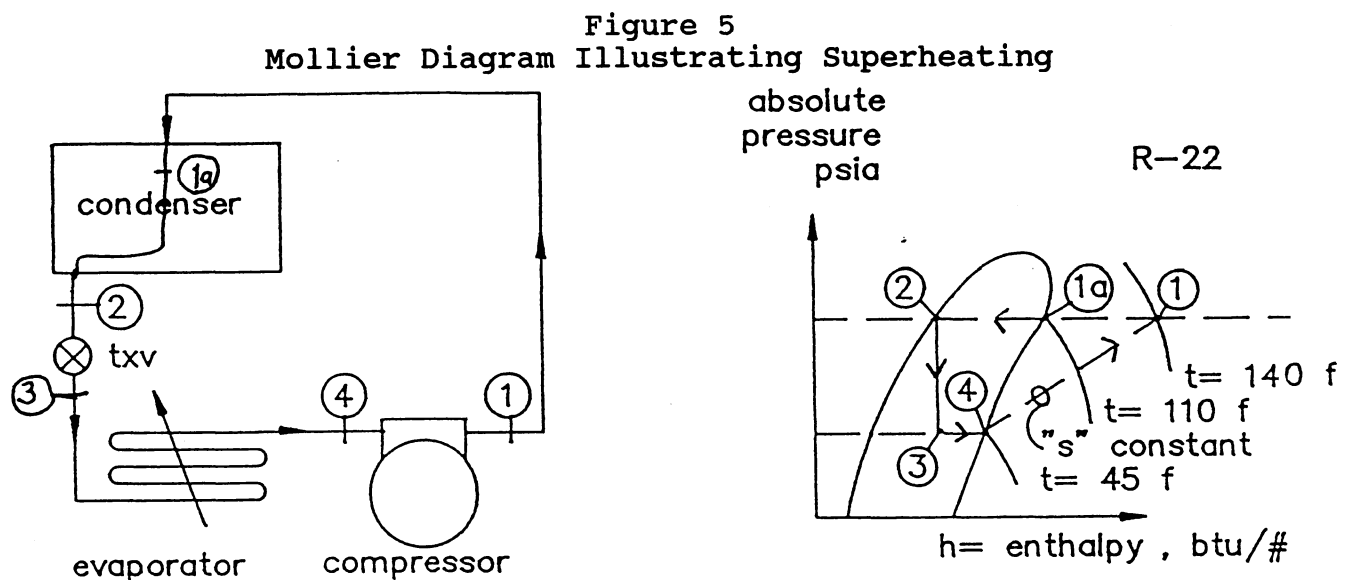


**FIGURE 4 Enthalpy (Btu/lb)
WITH LIQUID PRESSURE AMPLIFIER**

One limitation of the Liquid Pressure Amplifier is that it can only be used with reciprocating type compressors and cannot be used with centrifugal or screw compressors. Also, only "Freon" type refrigerants can be used with Hy-Save pumps which excludes the use of ammonia (the pump is made of brass which is destroyed by ammonia). A similar concept could be used, however, for ammonia. Finally, systems with capillary expansion devices cannot be used.

Desuperheating Operation

The purpose of refrigeration and air conditioning is to move heat from one place at a relatively lower temperature to another place at a relatively higher temperature. A refrigeration compressor is used to compress the low temperature and pressure refrigerant gases to a higher pressure and temperature where the heat can be rejected. When the refrigerant gases exit the compressor they are in a superheated state (see point 1 in Figure 5 below).



Common superheat temperatures range from 150 - 230 °F depending on the system head pressure and the refrigerant being used.

A desuperheater is simply a heat exchanger with the hot refrigerant gases on one side and a heat recovery fluid on the other. This heat exchanger is located between the compressor discharge and the condenser inlet or between points 1 and 1a in Figure 5. In the heat exchanger, the refrigerant gases are cooled and their temperature is reduced as the sensible heat is recovered. This process is known as desuperheating because the superheat of the gases is being removed as it approaches the saturation point (point 1a, Figure 5).

Typically, desuperheating can only recovery between 18 and 30% of the total heat that is rejected with the balance being rejected in the condenser. A common question which arises at this point is why not recover the latent heat in the condenser as well as the sensible heat? Many times desuperheating is used because it allows the heat recovery fluid to be heated to a much higher temperature than does condensation heat recovery. With condensation heat recovery, the temperature of the exiting heat recovery fluid is limited to the condensing temperature. If the heat exchanger is just being used to preheat the heat recovery fluid, then installation of an auxiliary waste heat condenser could be a better solution due to the increase in the amount of heat that could be recovered.

The most common refrigerants that are most effective for desuperheating are R-22, R-12, R-502, and R-717. Between 3,000 - 6,000 Btu/ton-hr are available from desuperheating depending on the refrigerant that is used and the condensing pressures (Brown, 1986). The most common uses for the heat that is recovered by desuperheating are to preheat domestic hot water or boiler feedwater. For heating DHW, most codes require that double wall vented heat exchangers be used so that leaks can be easily detected.

In general, two types of savings are obtained through desuperheating. First, there are the fuel savings due to the heat recovered from the refrigerant which can be used instead of a fuel such as natural gas. Secondly, there are electrical savings which occur due to the reduced condensing pressures caused by the addition of the desuperheater. In effect, when the desuperheater is added, the heat rejection surface area is increased which allows the condensing temperature to more closely approach the ambient temperature. According to desuperheater manufacturer estimates as well as those of experienced consultants, compressor electrical savings range from 3% to 5%. These savings necessarily depend on many factors, including the entering temperature of the heat recovery fluid (usually DHW), which is in turn affected by how much hot water is used and how long it resides in the storage tank. One of the major problems in determining the interaction of the desuperheater and the Hy-Save has been trying to determine exactly how much the condensing pressure is reduced by the addition of the

desuperheater. It seems that this kind of information is not readily available and none of the desuperheater manufacturers have made an effort to quantify the reduction in condensing pressure. For the purposes of this report, certain assumptions have been made with respect to this reduction and will be explained in a later section. One important note is that any reduction in condensing pressure that is obtained by installing a desuperheater must be tempered to allow for an increase in pressure drop that results from the addition of the heat exchanger itself in the refrigerant lines. A common figure for refrigerant side pressure drop on a desuperheater is 2 psig.

The costs of desuperheaters range between \$45 to \$100/ton plus installation depending on the type of heat exchanger used. Average paybacks range from 2.5 - 5 years depending on the amount of heat available and the amount which can be used. Also, an additional storage tank is sometimes necessary when the availability and the need for heat do not match.

INTERACTION OF DESUPERHEATING AND THE HY-SAVE

Now that the independent operation of the Hy-Save and desuperheating has been described, an analysis of how the two technologies are affected when applied simultaneously is presented.

When trying to predict the interaction of desuperheating and the Hy-Save, an attempt is made to answer the following questions:

- 1) What effect will the reduction in head pressure allowed by the Hy-Save have on the amount of heat available for recovery by desuperheating?
- 2) What effect will the drop in condensing pressure caused by desuperheating have on the Hy-Save savings?
- 3) What is the combined effect on dollar savings and payback for various refrigerants, tonnages, and load profiles?

The first two questions will be answered in this section while the third must wait until a later section where specific examples will be addressed along with some sensitivity analysis.

First, a very general example of a 20 ton R-22 unit is presented with the over-simplified load profiles shown in Tables 1 and 2 (more precise examples will be given in the next section). This unit is assumed to have a minimum condensing temperature of 100 °F. Notice that the condensing temperature is assumed to float 20 degrees above the ambient temperature. Also, the corresponding refrigerant flow and available waste heat are given in Tables 1 and 2. The details of how to calculate the refrigerant flow and

available waste heat are presented in the next section. For now, however, the focus will be only in looking at the general results of applying desuperheating and the Hy-Save simultaneously.

Table 1. Desuperheating without Hy-Save

Ambient Temp °F	Cond. Temp °F	Load Factor	Refrig. Flow lb/hr	Waste Ht. Avail Btu/hr
<u>Constant Load</u>				
100	120	1.00	3,688	66,375
80	100	1.00	3,688	55,313
60	100	1.00	3,688	55,313
40	100	1.00	3,688	55,313
<u>Variable Load</u>				
100	120	1.00	3,688	66,375
80	100	0.75	2,766	41,484
60	100	0.50	1,844	27,657
40	100	0.25	922	13,829

Table 2. Desuperheating with Hy-Save

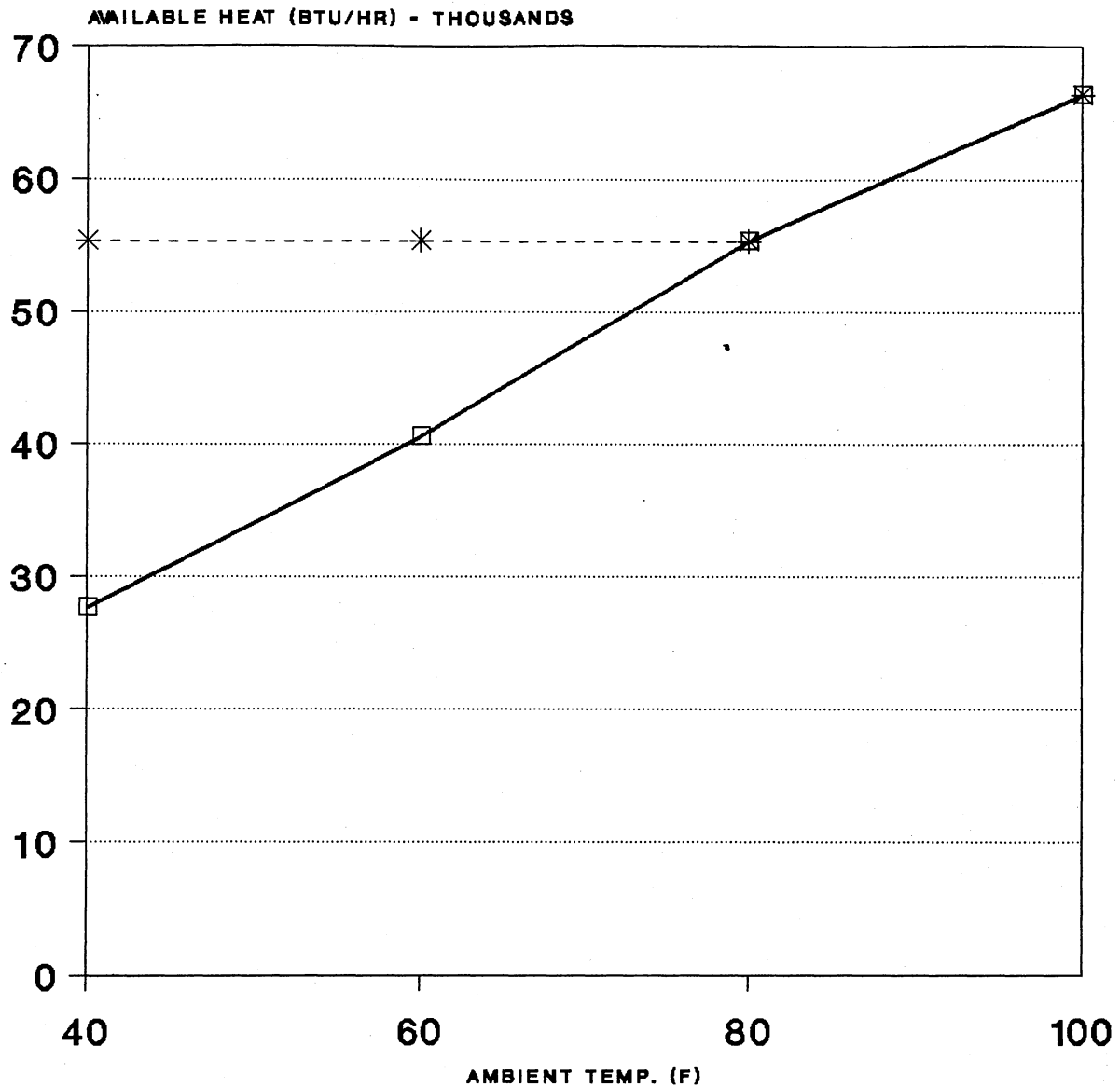
Ambient Temp °F	Cond. Temp °F	Load Factor	Refrig. Flow lb/hr	Waste Ht. Avail Btu/hr
<u>Constant Load</u>				
100	120	1.00	3,688	66,375
80	100	1.00	3,688	55,313
60	80	1.00	3,688	40,563
40	60	1.00	3,688	27,656
<u>Variable Load</u>				
100	120	1.00	3,688	66,375
80	100	0.75	2,766	41,484
60	80	0.50	1,844	20,282
40	60	0.25	922	6,914

Effect of Hy-Save on Desuperheating

We begin by looking at the effect that the reduction in head pressure allowed by the Hy-Save will have on the amount of heat available for recovery by desuperheating. The first consideration is the constant load case where for a full 20 ton load at all times. This is not a realistic case, but does establish the upper bound for the amount of waste heat that will be available. Plotting the appropriate data from Tables 1 and 2, Figure 6 can be constructed which shows the available waste heat vs. the ambient temperature for both cases with and without the Hy-Save. This shows that for a normal unit with no Hy-Save installed, the amount of waste heat available decreases as the ambient temperature decreases until the minimum condensing temperature of 100 °F (80 °F ambient) is reached. At this point the waste heat available remains constant even as the ambient drops to 60 °F. The reason for this maintained level of waste heat is that the condensing fans are cycled off and the condensing pressure is not allowed to fall any further.

For the case with the Hy-Save installed, the amount of waste heat available is unchanged from the previous case for ambient temperatures between 80 and 100°F (condensing temperatures from 100 to 120°F). The reason for this is that the Hy-Save is not activated until the condensing temperature drops below the previous allowed minimum (100°F). As the ambient temperature drops below 80°F, the adverse effect of the Hy-Save on desuperheating can be

FIGURE 6
HEAT RECOVERY VS. AMBIENT TEMP.
20 TON R-22 UNIT, CONSTANT LOAD



—□— WITH HY-SAVE -*- WITHOUT HY-SAVE

• COND. TEMP FLOATS 20F ABOVE AMBIENT

detected as it allows the condensing temperature to eventually fall to 60°F (40°F ambient). The reason that the available waste heat decreases as the condensing temperature falls can be seen from Figure 7. Figure 7 shows the basic cycle (points 1-2-3-4) with a maximum condensing temperature of 120°F. When the condensing pressure falls to 100°F, the cycle becomes 1a-2a-3a-4. As you can see from this modified cycle, there is less superheat available between points 1a and the saturation line than were available when the condensing temperature was 120°F. The reason for this decrease in superheat is that the compressor does not have to work as hard since the condensing pressure has been reduced, and therefore, less energy is added to the refrigerant by the compressor. Another point to notice from Figure 7 is that as the condensing pressure falls, the net refrigeration effect increases meaning fewer pounds of refrigerant have to be circulated to obtain the same tonnage effect. The net refrigeration effect is given between points 3 and 4a for a condensing pressure of 120°F and between 3a and 4a for 100°F and so on. This reduction in circulated refrigerant also reduces the amount of waste heat that is available by desuperheating.

Next, effect of the Hy-Save on Desuperheating is explored for a load that decreases as the ambient temperature is reduced (a more realistic case). Figure 8 utilizes the appropriate data from Tables 1 and 2 and presents the cases with and without the Hy-Save Installed. for a normal unit with no Hy-Save, Figure 8 shows that as the ambient temperature falls from 100 to 80°F the amount of

-30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

"FREON" 22

REFRIGERANT

TEMPERATURE in °F ENTROPY in Btu/(lb)(°R)

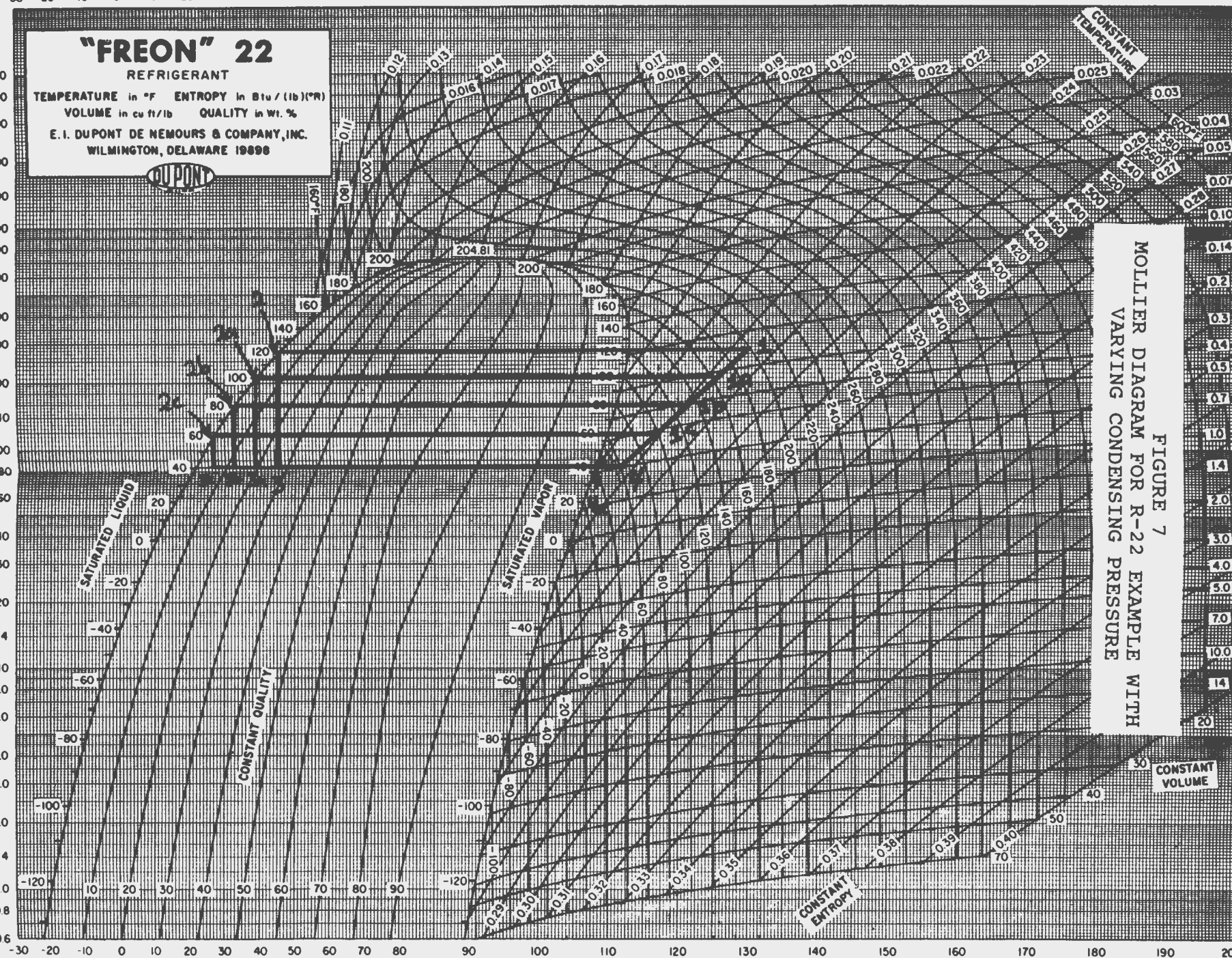
VOLUME in cu ft/lb QUALITY in Wt. %

E. I. DUPONT DE NEMOURS & COMPANY, INC.
WILMINGTON, DELAWARE 19898



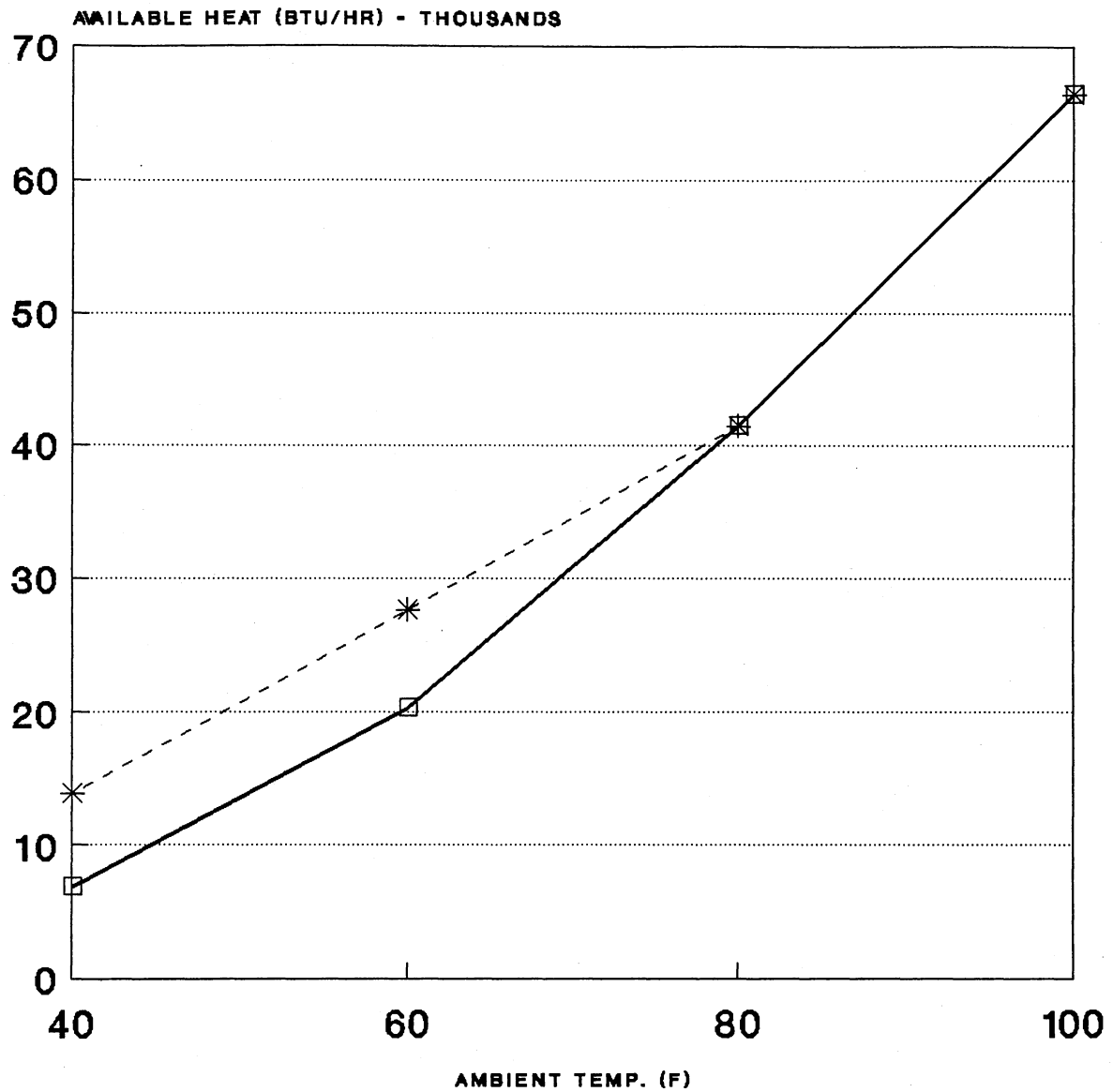
ABSOLUTE PRESSURE (LBS. PER SQUARE INCH)

FIGURE 7
MOLLIER DIAGRAM FOR R-22 EXAMPLE WITH
VARYING CONDENSING PRESSURE



ENTHALPY (BTU PER LB ABOVE SATURATED LIQUID AT -40°F)

FIGURE 8
HEAT RECOVERY VS. AMBIENT TEMP.
20 TON R-22 UNIT, VARIABLE LOAD



—□— WITH HY-SAVE -*- WITHOUT HY-SAVE

COND. TEMP FLOATS 20F ABOVE AMBIENT

waste heat available decreases, as before with a constant load, but at a greater rate. The reason for this higher rate of decrease is that now the load is falling off in addition to the reduction in condensing temperature. The decrease in condensing temperature means that the work per pound of refrigerant is reduced. In addition, as the load drops off, the number of pounds of refrigerant needed to produce the desired cooling are also reduced. Finally, as the condensing pressure drops, the net refrigeration effect increases meaning that even less refrigerant is needed.

Below 80°F ambient temperature, the unit without the Hy-Save continues to exhibit a reduction in available waste heat, but the rate of decrease is less. The reason for this is that at 80°F ambient, the minimum condensing temperature has been reached and the affects seen are only from the reduction in load at all temperatures below this.

For the case with the Hy-Save installed, Figure 8 shows that no difference exists between the two cases between 80°F and 100°F ambient, as before. Once again this is due to the fact that the Hy-Save is not activated except at ambient temperatures below 80°F. As the ambient temperature drops below 80°F, however, the amount of available heat begins to decrease at a greater rate than for the case with no Hy-Save installed. The reason for this greater rate of decrease in recoverable heat is due to the fact that the Hy-Save allows a reduction in the condensing temperature below the minimum value allowed by the unit with no Hy-save installed. And, as

mentioned before, a decrease in condensing temperature results in a reduction in the work required by the compressor, and hence the amount of heat available in the refrigerant.

In summary, installation of a Hy-Save pump with a desuperheater will always act to reduce the amount of waste heat available for recovery. This negative effect is amplified for load profiles which decrease significantly with decrease in outdoor temperature (as is the case for a thermally light building for example). Therefore, negative impact of the Hy-Save on desuperheating can be minimized, but by no means eliminated, when used in applications with heavy cooling loads even when outdoor temperatures are low (very thermally heavy buildings or process loads would be examples).

Effect of Desuperheating on Hy-Save

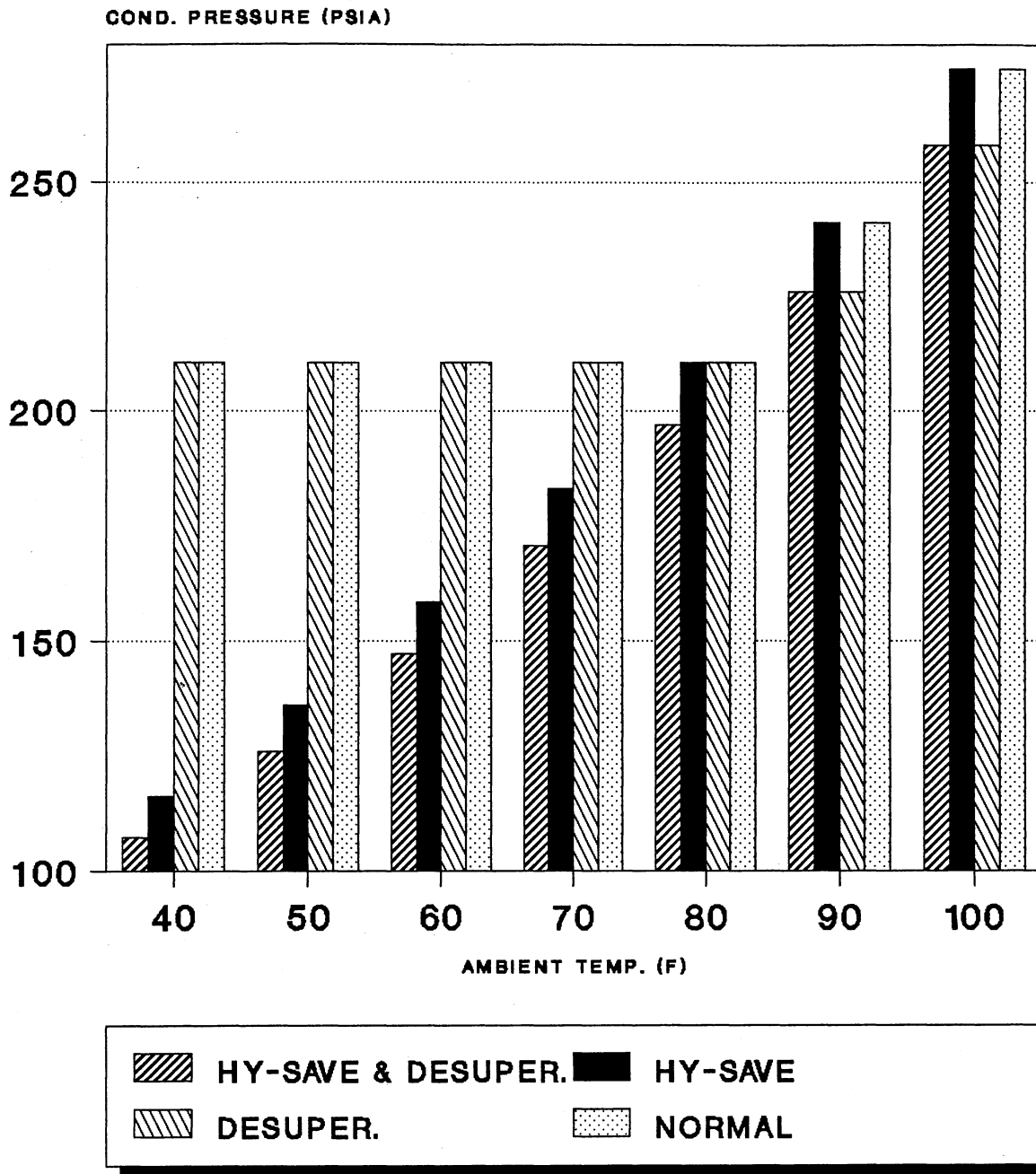
Next, effect of desuperheating on the operation of the Hy-Save is explored. As mentioned in an earlier section, the Hy-Save allows refrigeration units to operate at low condensing pressures during periods of low ambient temperature. The savings occur because operation at lower condensing pressures requires less compressor work. Therefore, to predict the effect that desuperheating will have on the Hy-Save, it is necessary to determine exactly how desuperheating alters the condensing pressure. As mentioned earlier, this is exactly the type of information that is not readily available at this time. It is clear that the addition of

a desuperheater decreases the condensing pressure, but the size of the reduction and how it varies with load and ambient temperature are not well established. However, in the article "Heat Recovery in Refrigeration: II.", Otto Nussbaum gives desuperheating examples for R-22, R-12, and R-502. These examples include the condensing temperature before and after the installation of a desuperheater. Unfortunately, only one data point is given for 95°F ambient temperature. The work in this paper is based on the information given in the article referred to above and assumes that the reductions in condensing pressure caused by desuperheating remain constant as the ambient temperature and load vary. For the R-22 example a reduction in condensing temperature of 6°F is used.

Figure 9 presents the condensing pressure plotted vs. ambient temperature for four different cases. The first case is a normal unit which has no desuperheating or Hy-Save. The figure shows, for this case, that condensing pressure decreases as the ambient temperature decreases until the minimum condensing pressure of 211 psia (corresponds to a condensing temperature of 100°F) is reached. It should be noted that for the normal unit, the condensing temperature floats 20°F above the ambient temperature.

The second case is for a unit which only has the Hy-Save installed. Figure 9 shows for this case that, unlike the normal unit, the condensing pressure continues to decrease below the previous low limit of 211 psia. This is no surprise since this is the advantage of the Hy-Save.

FIGURE 9
COND. PRESSURE VS. AMBIENT TEMP.
 20 TON R-22 UNIT, CONSTANT LOAD



COND. TEMP FLOATS 20F ABOVE AMBIENT

The third case involves desuperheating only. Figure 9 shows, for this case, that savings from reduced condenser pressure result only between ambient temperature from 80°F to 100°F. This reduction is a result of the extra surface area provided by the desuperheater for heat exchange. Below 80°F the curve for the normal unit and that for the unit with desuperheating correspond exactly. This is due to the fact that, in both cases, the minimum condensing temperature of 100°F (211 psia condensing pressure) is encountered.

The most interesting case is for the Hy-Save and desuperheating combined. This curve illustrates the 6°F reduction in condensing temperature resulting from installation of a desuperheater and shows that savings will result from reduced compressor work over all ranges of ambient temperature.

Thus, it has been established that desuperheating has a positive effect on the Hy-Save technology when the two are applied together. As discussed in the last section, however, when the Hy-Save allows operation at low condensing pressures, the recoverable heat through desuperheating decreases dramatically. Therefore, it remains to establish the net result of these two offsetting interactive effects. In the next section, more detailed examples are given with a complete explanation of the calculation procedures that were developed.

CALCULATION METHODOLOGY

In order to demonstrate the calculation procedures used, an example is presented. There are three main variables which effect the calculation including tonnage of unit, type (air or water cooled), load profile (light, medium, or heavy), and refrigerant used. These variables are given below for this particular example.

Example Parameters:

Unit tonnage:	20 tons
Unit type:	Air Cooled
Load Profile:	Medium
Refrigerant:	R-22

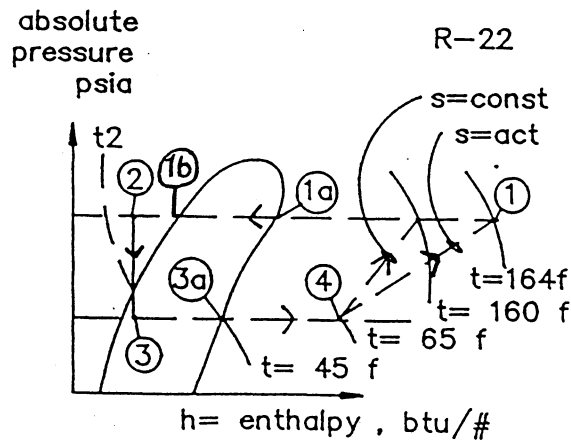
Once the parameters above are established, calculations can be performed to determine the energy consumption of the cooling unit without a desuperheater or Hy-Save pump installed. This calculation establishes the baseline by which all other alternatives are compared. These calculations are performed for the given example in Table 3. The calculations presented in Table 3 are based on bin data for Tinker Air Force Base given in the first two columns. The existing condensing temperature was obtained by assuming that, for an air cooled condenser, the condensing temperature floats 20°F above ambient temperature. For this example, the minimum condensing temperature was assumed to be 105°F.

The load profile given in the fourth column is a linear function of ambient outdoor temperature and should be representative of a

thermally medium building (see Figure 11 in the next section).

The parameters H_1 , H_{1a} , and H_3 are enthalpy values obtained from a Mollier diagram for R-22 for the given condensing temperatures. These parameters are based on the numbering system shown below in Figure 10.

Figure 10
Cycle Diagram Numbering Schematic



Source: Refrigeration Systems for Air Conditioning and Industry

Other values of enthalpy which were used in the calculations, but which did not vary with condensing temperature are given below:

$$\begin{aligned} H_{3a} &= 107.94 \text{ Btu/lb} \\ H_2 &= H_3 \end{aligned}$$

$$H_4 = 111.50 \text{ Btu/lb}$$

The net refrigeration effect which is given in column 8 of Table 3 was obtained as shown below (all example calculations given in this section are for the 102 °F temperature bin).

$$\begin{aligned}
 \text{Net Refrigeration Effect} &= H_{3a} - H_3 \\
 &= 107.94 \text{ Btu/lb} - 49.76 \text{ Btu/lb} \\
 &= 58.18 \text{ Btu/lb}
 \end{aligned}$$

The refrigerant flow for each temperature bin is calculated as shown below

$$\begin{aligned}
 \text{Refrig. Flow} &= (12,000 \text{ Btu/ton-hr}) \times (20 \text{ tons}) \\
 &\quad \times (\text{load factor}) \times (1/\text{net refriger. effect}) \\
 &= 12,000 \text{ Btu/ton-hr} \times 20 \text{ tons} \times 1.0 \\
 &\quad \times (1/58.18 \text{ Btu/lb}) \\
 &= 4,125.13 \text{ lbs/hr}
 \end{aligned}$$

The work required for each temperature bin is calculated as follows:

$$\begin{aligned}
 \text{Work} &= H_1 - H_4 \\
 &= 134.00 \text{ Btu/lb} - 111.5 \text{ Btu/lb} \\
 &= 22.50 \text{ Btu/lb}
 \end{aligned}$$

The electric power and energy consumption for each temperature bin are calculated as shown below. (Note that a motor efficiency of 85% has been assumed).

$$\begin{aligned}
 \text{Power Required} &= \text{Refrig. Flow} \times \text{Work} \times (1/3412 \text{ Btu/kw-hr}) \\
 &\quad \times (1/\text{elect. efficiency}) \\
 &= 4,125.13 \text{ lb/hr} \times 22.5 \text{ Btu/lb} \\
 &\quad \times (1/3412 \text{ Btu/kw-hr}) \times (1/0.85) \\
 &= 32.0 \text{ kW}
 \end{aligned}$$

$$\begin{aligned}
 \text{Energy Consumption} &= \text{Power} \times \text{bin hours} \\
 &= 32.0 \text{ kW} \times 2 \text{ hours} \\
 &= 64 \text{ kWh}
 \end{aligned}$$

Table 3

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 20 TONS LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG						POWER *	ENERGY		
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64
97	104	127	0.94	132.82	112.49	48.05	59.89	3,766.91	21.32	27.7	2,880
92	296	122	0.88	131.64	112.44	46.37	61.57	3,430.24	20.14	23.8	7,051
87	407	117	0.82	130.46	112.35	44.71	63.23	3,112.45	18.96	20.3	8,281
82	618	112	0.76	129.28	112.22	43.08	64.86	2,812.21	17.78	17.2	10,655
77	776	107	0.70	128.10	112.06	41.47	66.47	2,527.46	16.60	14.5	11,226
72	1009	105	0.64	127.63	111.99	40.83	67.11	2,288.78	16.13	12.7	12,844
67	747	105	0.58	127.63	111.99	40.83	67.11	2,074.21	16.13	11.5	8,617
62	642	105	0.52	127.63	111.99	40.83	67.11	1,859.63	16.13	10.3	6,640
57	601	105	0.46	127.63	111.99	40.83	67.11	1,645.06	16.13	9.1	5,499
52	684	105	0.40	127.63	111.99	40.83	67.11	1,430.49	16.13	8.0	5,442
47	569	105	0.34	127.63	111.99	40.83	67.11	1,215.91	16.13	6.8	3,848
42	667	105	0.28	127.63	111.99	40.83	67.11	1,001.34	16.13	5.6	3,715
37	621	105	0.22	127.63	111.99	40.83	67.11	786.77	16.13	4.4	2,717
32	504	105	0.16	127.63	111.99	40.83	67.11	572.19	16.13	3.2	1,604
27	229	105	0.10	127.63	111.99	40.83	67.11	357.62	16.13	2.0	455
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
8,476											91,538

* Motor efficiency of 85% assumed

For the 20 ton unit given in this example, the annual energy usage would be 91,538 kWh as shown in Table 3.

The next step in the calculation methodology is to determine the energy and dollar savings for installing a desuperheater only. For our example, these calculations are shown in Table 4. The first twelve columns of Table 4 are calculated similarly to Table 3 for the baseline. The condensing temperatures are reduced 6°F, however, for the case with the desuperheater as discussed in previous sections, with the low limit of 105°F remaining the same. It can be seen from the energy consumption column (column 12) of Table 4 that the electric power is reduced from 91,538 kWh to 88,145 kWh due to the addition of the desuperheater.

The Available waste heat (column 15) and Total waste heat (column 16) are calculated as follows:

$$\begin{aligned}\text{Avail. Waste Heat} &= H_1 - H_{1a} \\ &= 132.58 \text{ Btu/lb} - 112.45 \text{ Btu/lb} \\ &= 20.1 \text{ Btu/lb}\end{aligned}$$

$$\begin{aligned}\text{Total Waste Heat} &= \text{Avail. Waste heat} \times \text{Refrig. flow} \\ &\quad \times \text{bin hours} \times (1 \text{ MMBtu}/10^6 \text{ Btu}) \\ &= 20.1 \text{ Btu/lb} \times 3,985.39 \text{ lb/hr} \\ &\quad \times 2 \text{ hours} \times (1 \text{ MMBtu}/10^6 \text{ Btu}) \\ &= 0.16 \text{ MMBtu}\end{aligned}$$

The dollar savings for installing a desuperheater are calculated as shown below assuming a gas cost of \$3.20/MMBtu, an electric cost of \$0.034/kWh, and a boiler efficiency of 80 percent.

Table 4

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

	Dry		Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *		PREV. ENERGY		ELECT. SAVINGS KWH	WASTE HT.		TOTAL		DOLLAR **
	Bulb Temp.	Hours (H)	Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB			CONSMPT KW	ENERGY KWH	ENERGY CONSMPT KWH	CONSMPT KWH		AVAIL. BTU/LB	WASTE HT. MMBTU	WASTE HT. MMBTU	SAVINGS \$	
	102	2	126	1.00	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64		6	20.10	0.16		0.85	
	97	104	121	0.94	131.40	112.43	46.03	61.91	3,644.00	19.90	25.0	2,600	2,880		280	18.97	7.19		38.26	
	92	296	116	0.88	130.22	112.32	44.39	63.55	3,323.37	18.72	21.5	6,350	7,051		701	17.90	17.61		94.28	
	87	407	111	0.82	129.04	112.20	42.75	65.19	3,018.87	17.54	18.3	7,431	8,281		851	16.84	20.69		111.68	
	82	618	106	0.76	127.86	112.03	41.15	66.79	2,730.95	16.36	15.4	9,520	10,655		1,134	15.83	26.72		145.43	
	77	776	105	0.70	127.63	111.99	40.83	67.11	2,503.35	16.13	13.9	10,804	11,226		422	15.64	30.38		135.87	
20	72	1009	105	0.64	127.63	111.99	40.83	67.11	2,288.78	16.13	12.7	12,844	12,844		0	15.64	36.12		144.47	
	67	747	105	0.58	127.63	111.99	40.83	67.11	2,074.21	16.13	11.5	8,617	8,617		0	15.64	24.23		96.93	
	62	642	105	0.52	127.63	111.99	40.83	67.11	1,859.63	16.13	10.3	6,640	6,640		0	15.64	18.67		74.69	
	57	601	105	0.46	127.63	111.99	40.83	67.11	1,645.06	16.13	9.1	5,499	5,499		0	15.64	15.46		61.85	
	52	684	105	0.40	127.63	111.99	40.83	67.11	1,430.49	16.13	8.0	5,442	5,442		0	15.64	15.30		61.21	
	47	569	105	0.34	127.63	111.99	40.83	67.11	1,215.91	16.13	6.8	3,848	3,848		0	15.64	10.82		43.28	
	42	667	105	0.28	127.63	111.99	40.83	67.11	1,001.34	16.13	5.6	3,715	3,715		0	15.64	10.45		41.78	
	37	621	105	0.22	127.63	111.99	40.83	67.11	786.77	16.13	4.4	2,717	2,717		0	15.64	7.64		30.57	
	32	504	105	0.16	127.63	111.99	40.83	67.11	572.19	16.13	3.2	1,604	1,604		0	15.64	4.51		18.04	
	27	229	105	0.10	127.63	111.99	40.83	67.11	357.62	16.13	2.0	455	455		0	15.64	1.28		5.12	
	22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0		0	0.00	0.00		0.00	
	17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0		0	0.00	0.00		0.00	
	12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0		0	0.00	0.00		0.00	
8,476											88,145		91,538	3,394		247.24		\$1,104		

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

$$\begin{aligned}
 \text{Dollar Savings} &= 6 \text{ kWh} \times \$0.034/\text{kWh} + 0.16 \text{ MMBtu} \\
 &\quad \times (1/0.8) \times \$3.2/\text{MMBtu} \\
 &= \$0.85
 \end{aligned}$$

The calculations in Table 4 for installation of a desuperheater result in a total waste heat recovery of 247.24 MMBtu/yr and a dollar savings of \$1,104/yr.

The next step is to calculate the savings for installing a Hy-Save pump alone. These calculations are performed using a modified version of Table 3. The calculations for our example are shown in Table 5. The first twelve columns of Table 5 are calculated exactly as in Table 3. In addition, there is a column for the previous energy consumption which shows the energy consumption of the normal system before any modifications are made. The numbers in this column are the same as the last column in Table 3 which is the baseline energy consumption for the unit. Next, a calculation of additional fan energy consumption has been added to account for the fact that the condensing fans will run more hours after the installation of the Hy-Save unit. The methodology for calculating the additional fan power is based on the method developed by the Oregon State Energy Analysis and Diagnostics Center and is outlined below.

$$\text{Fan Power} = \text{FP} \times \text{H} \times (\text{OH}/\text{H}_t) \times [\text{DT}_e/(\text{T}_{cp}-\text{T}) - \text{DT}_e/(\text{T}_{ce}-\text{T})]$$

Where,

FP = Fan horsepower
 H = Number of bin hours in a particular bin
 OH = Annual operating hours

EXAMPLE: HY-SAVE ONLY

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG		WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	Add'l ** Fan KWH	ELECT. SAVINGS KWH	DOLLAR *** SAVINGS \$
							EFFECT BTU/LB	REFRIG. FLOW LBS/HR				KWH			
102	2	132	1.00	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64	64	0	0	0.00
97	104	127	0.94	132.82	112.49	48.05	59.89	3,766.91	21.32	27.7	2,880	2,880	0	0	0.00
92	296	122	0.88	131.64	112.44	46.37	61.57	3,430.24	20.14	23.8	7,051	7,051	0	0	0.00
87	407	117	0.82	130.46	112.35	44.71	63.23	3,112.45	18.96	20.3	8,281	8,281	0	0	0.00
82	618	112	0.76	129.28	112.22	43.08	64.86	2,812.21	17.78	17.2	10,655	10,655	0	0	0.00
77	776	107	0.70	128.10	112.06	41.47	66.47	2,527.46	16.60	14.5	11,226	11,226	0	0	0.00
72	1009	102	0.64	126.92	111.85	39.55	68.39	2,245.94	15.42	11.9	12,049	12,844	60	735	24.98
67	747	97	0.58	125.74	111.63	37.99	69.95	1,989.99	14.24	9.8	7,299	8,617	104	1,215	41.31
62	642	92	0.52	124.56	111.40	36.43	71.51	1,745.21	13.06	7.9	5,045	6,640	128	1,467	49.87
57	601	87	0.46	123.38	111.13	34.90	73.04	1,511.50	11.88	6.2	3,721	5,499	148	1,629	55.40
52	684	82	0.40	122.20	110.86	33.38	74.56	1,287.55	10.70	4.8	3,249	5,442	195	1,997	67.91
47	569	77	0.34	121.02	110.55	31.88	76.06	1,072.84	9.52	3.5	2,004	3,848	181	1,663	56.55
42	667	72	0.28	119.84	110.24	30.39	77.55	866.54	8.34	2.5	1,662	3,715	230	1,823	61.97
37	621	67	0.22	118.66	109.91	28.92	79.02	668.19	7.16	1.6	1,024	2,717	228	1,465	49.79
32	504	62	0.16	117.48	109.56	27.46	80.48	477.14	5.98	1.0	496	1,604	195	913	31.03
27	229	60	0.10	117.00	109.49	27.17	80.77	297.14	5.50	0.6	129	455	79	247	8.41
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
8,476											76,836	91,538	1,549	13,154	\$447

* Motor effeciency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

H_t = Total bin hours
 DT_e = Existing temperature difference between ambient
 and the condensing temperature
 T_{cp} = Proposed condensing temperature
 T_{ce} = Existing condensing temperature
 T = Bin temperature

The major difference between Table 5 and the other tables is that the condensing temperature (column 3) is allowed to drop below 105°F to a minimum condensing temperature of 60°F. This reduction in condensing temperature is the major advantage of the Hy-Save and results in reduced power consumption of the unit.

For the given example, the Hy-Save will result in a new compressor energy consumption of 76,836 kWh or a reduction of 13,154 kWh (including the 1,549 kWh additional fan power). Assuming \$0.034/kWh, the resulting annual dollar savings is \$447/yr.

The energy and dollar savings for installing the two technologies separately have now been established. The next step is to calculate the total savings for installing a desuperheater and Hy-Save simultaneously. In order to do this, Table 4 was modified. The new calculations are shown in Table 6. The calculations in Table 6 are identical to those in Table 4 with the exception that a column has been added to account for additional condensing fan power as described for Table 5. This new table uses a minimum condensing temperature of 60°F instead of 105°F and the associated new enthalpies are taken from a Mollier diagram for R-22. Table 6 indicates that the total electrical energy consumption is reduced to 67,850 kWh resulting in a savings of 21,341 kWh/yr. The total

Table 6

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	NET REGRIG								POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT KWH	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
				H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK										
				BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB										
102	2	126	1.00	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64	0	6	20.10	0.16	0.85		
97	104	121	0.94	131.40	112.43	46.03	61.91	3,644.00	19.90	25.0	2,600	2,880	0	280	18.97	7.19	38.26		
92	296	116	0.88	130.22	112.32	44.39	63.55	3,323.37	18.72	21.5	6,350	7,051	0	701	17.90	17.61	94.28		
87	407	111	0.82	129.04	112.20	42.75	65.19	3,018.87	17.54	18.3	7,431	8,281	0	851	16.84	20.69	111.68		
82	618	106	0.76	127.86	112.03	41.15	66.79	2,730.95	16.36	15.4	9,520	10,655	0	1,134	15.83	26.72	145.43		
77	776	101	0.70	126.68	111.85	39.55	68.39	2,456.50	15.18	12.9	9,978	11,226	83	1,165	14.83	28.27	152.70		
72	1009	96	0.64	125.50	111.63	37.99	69.95	2,195.85	14.00	10.6	10,695	12,844	206	1,942	13.87	30.73	188.96		
67	747	91	0.58	124.32	111.40	36.43	71.51	1,946.58	12.82	8.6	6,428	8,617	206	1,983	12.92	18.79	142.58		
62	642	86	0.52	123.14	111.13	34.9	73.04	1,708.65	11.64	6.9	4,403	6,640	213	2,025	12.01	13.17	121.53		
57	601	81	0.46	121.96	110.86	33.38	74.56	1,480.69	10.46	5.3	3,210	5,499	225	2,064	11.10	9.88	109.68		
52	684	76	0.40	120.78	110.55	31.88	76.06	1,262.16	9.28	4.0	2,762	5,442	281	2,399	10.23	8.83	116.88		
47	569	71	0.34	119.60	110.24	30.39	77.55	1,052.22	8.10	2.9	1,672	3,848	250	1,926	9.36	5.60	87.88		
42	667	66	0.28	118.42	109.91	28.92	79.02	850.42	6.92	2.0	1,353	3,715	310	2,052	8.51	4.83	89.06		
37	621	61	0.22	117.24	109.56	27.46	80.48	656.06	5.74	1.3	806	2,717	301	1,610	7.68	3.13	67.24		
32	504	60	0.16	117.00	109.49	27.17	80.77	475.42	5.50	0.9	454	1,604	200	950	7.51	1.80	39.49		
27	229	60	0.10	117.00	109.49	27.17	80.77	297.14	5.50	0.6	129	455	72	254	7.51	0.51	10.69		
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00		
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00		
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00		
8,476											67,850	91,538	2,348	21,341		197.91	\$1,517		

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

waste heat is 197.91 MMBtu/yr and the total dollar savings is \$1,517/yr.

The results of these calculations for our example, and for other cases, are analyzed in the next section.

RESULTS AND SENSITIVITY ANALYSIS

To aid in analyzing the results of the calculations in the previous section for our example, an economic summary is presented in Table 7. This table presents the dollar savings, implementations cost, and simple payback for each of the technologies installed together. Table 7 shows that the dollar savings for the two technologies installed separately are \$1,104/yr for desuperheating and \$447/yr for the Hy-Save. When the two technologies are installed together the combined savings is \$1,517/yr which is slightly less than the total savings of the two installed separately (\$1,551/yr) indicating that there is a small negative impact on the total savings when the two are installed together. This difference is due to the fact, as discussed in earlier sections, that the amount of waste heat from desuperheating is reduced from 247.24 MMBtu/yr to 197.91 MMBtu/yr when installed with a Hy-Save. However, this negative impact is almost completely balanced by the increased electrical savings that result from the Hy-Save when installed with desuperheating.

It is also important to notice for this case that the payback for installing a desuperheater and a Hy-Save separately are 2.6 and 3.4

Table 7

ECONOMIC SUMMARY

TONNAGE: 20 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$1,104/yr
Implementation Cost: \$2,828 (ht. exch. & pump installed)
Payback: 2.6 years

HY-SAVE ONLY

Annual Dollar Savings: \$447/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 3.4 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$1,517/yr
Implementation Cost: \$4,328 (combined cost)
Payback: 2.9 years

years respectively. When the two are installed together, however, the resulting payback is 2.9 years. In effect, what is happening is that the desuperheating savings help to pay for the installation of the Hy-Save pump, reducing its payback from 3.4 to a payback of only 2.9 years for the total package.

In order to establish the response of our calculations to certain variables, a simplified sensitivity analysis was performed. The variables which were considered were load profile, tonnage of unit, and the refrigerant used. The object of this analysis was to determine the effect of these variables on the payback and dollar savings of the two technologies when they are installed separately and together.

To begin, three simplified load profiles were considered and were defined to be light, medium, and heavy. These three profiles were defined to be a linear function of ambient outdoor temperature. A plot of the three profiles is given in Figure 11. For each of these three profiles, calculations were performed as in the previous section. For these calculations, the tonnage was assumed to be 20 tons and the refrigerant used was R-22. These calculations are given in Appendix A. The important results, however, are plotted in Figures 12 and 13. Figure 12 gives the dollar savings for each of the three load profiles for the desuperheater only, the Hy-Save only and finally, the two technologies installed together. As might be expected, the best dollar savings for each of the three cases occurs for the heavy

FIGURE 11
LOAD PROFILES

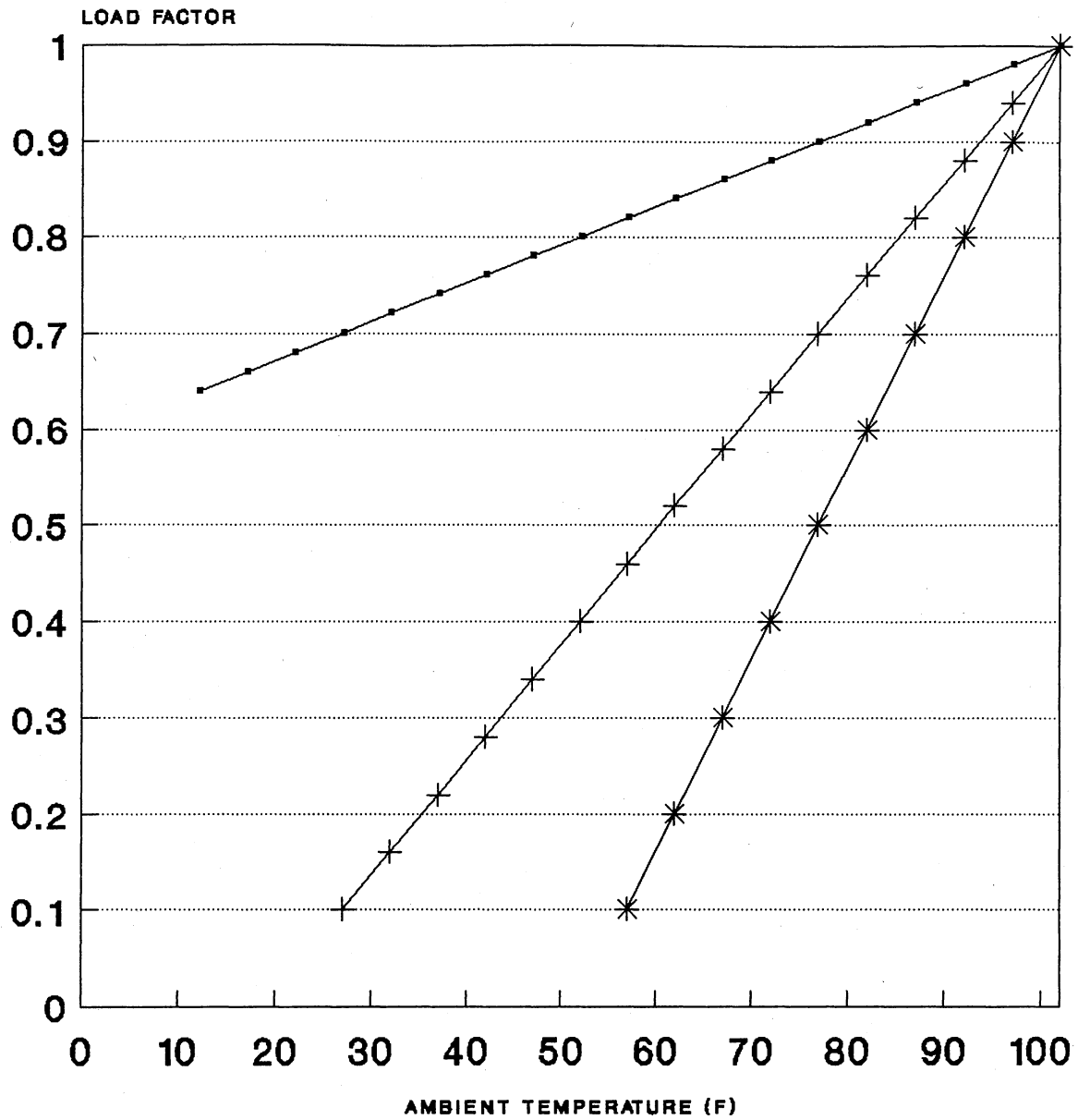


FIGURE 12
VARIATION WITH LOAD PROFILE
\$ SAVINGS VS. PROFILE (20 TON, R-22)

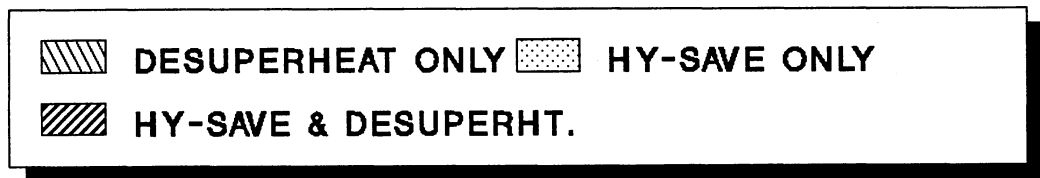
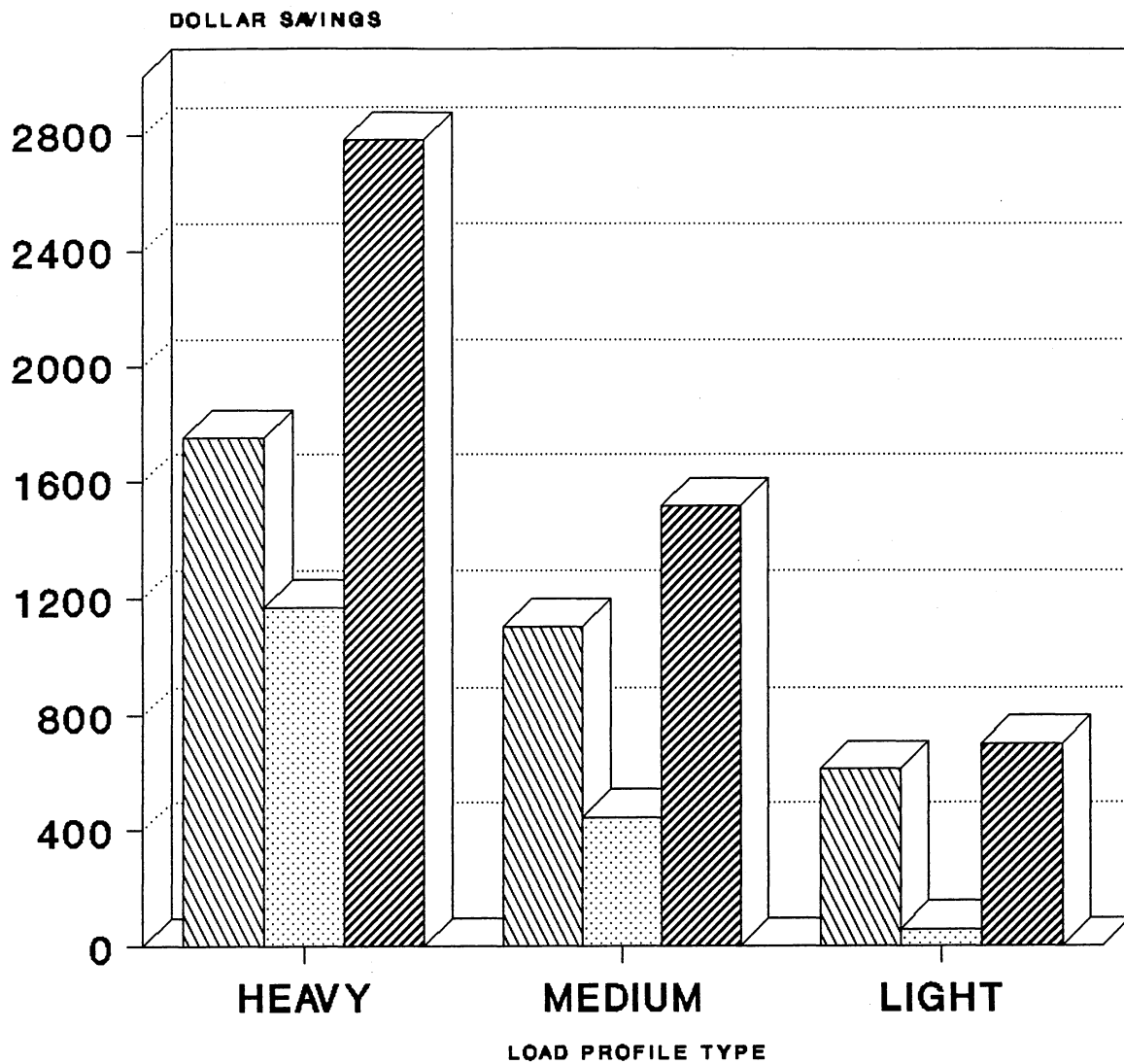
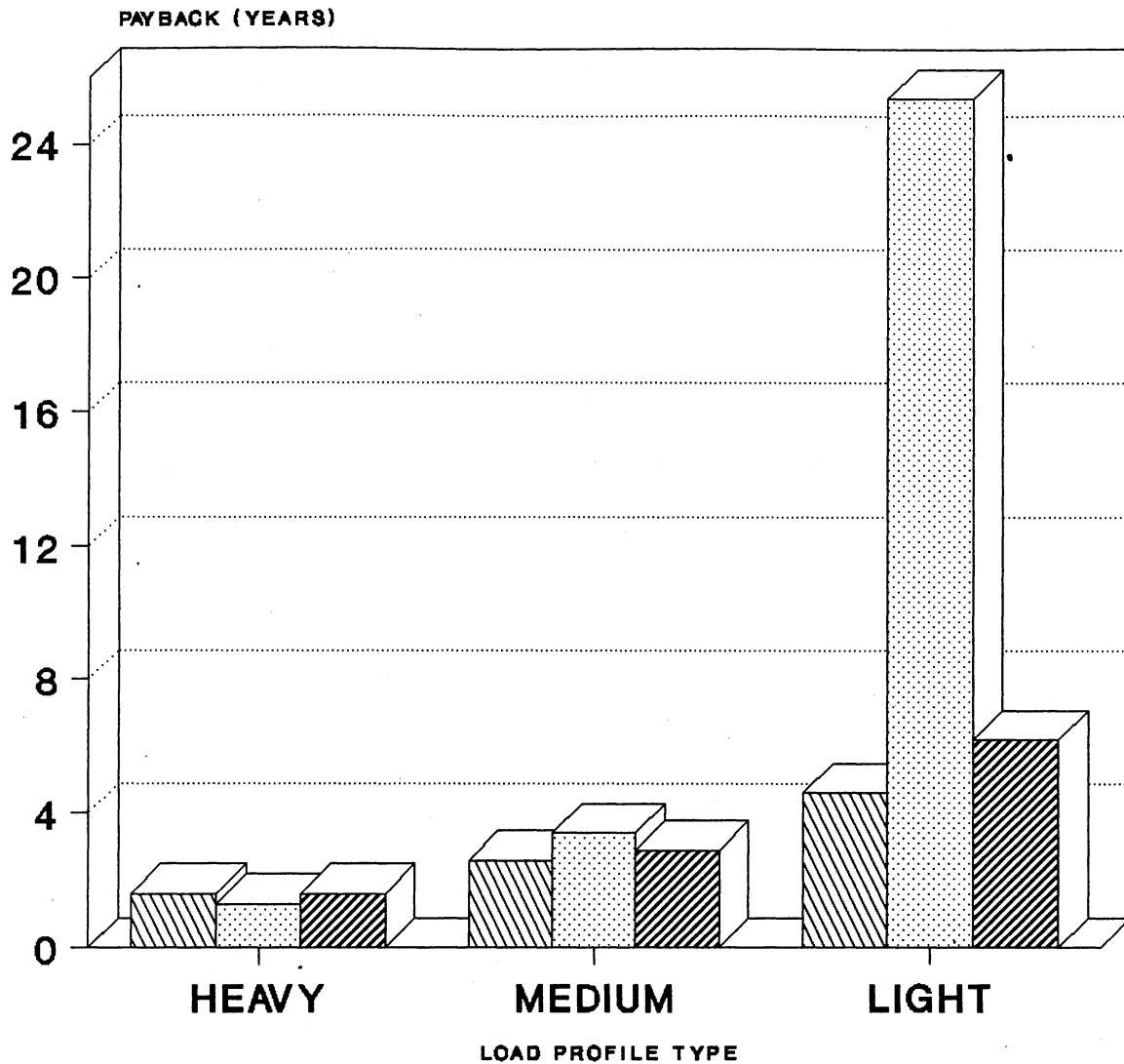


FIGURE 13
VARIATION WITH LOAD PROFILE
PAYBACK VS. PROFILE TYPE (20 TON, R-22)



DESUPERHEAT ONLY HY-SAVE ONLY
HY-SAVE & DESUPERHT.

profile which will result in the most operating hours of the refrigeration unit. The dollar savings drop off significantly for the light profile as compared to the heavy profile. This is especially true for the case of the Hy-Save installed by itself which has an annual dollar savings below \$100. It should also be noted that the savings for the case when the two technologies are installed together are somewhat less than the sum of the savings when the desuperheater and the Hy-Save are installed separately. This indicates that there is a small overall negative interactive effect between the two technologies.

Figure 13 shows the simple payback for each of the cases as a function of the load profile. This figure indicates that all paybacks are very good for the heavy and the medium profiles. For the light profile, however, the payback for the Hy-Save individually is more than 24 years. The reason for this is that for the light profile, there are not many operating hours at low ambient temperatures which the Hy-Save can take advantage of. The overall payback for the light profile combined installation is a very reasonable 6.2 years. In this case, the savings from the desuperheater helped to pay for the installation of the Hy-Save which was not economically feasible on its own.

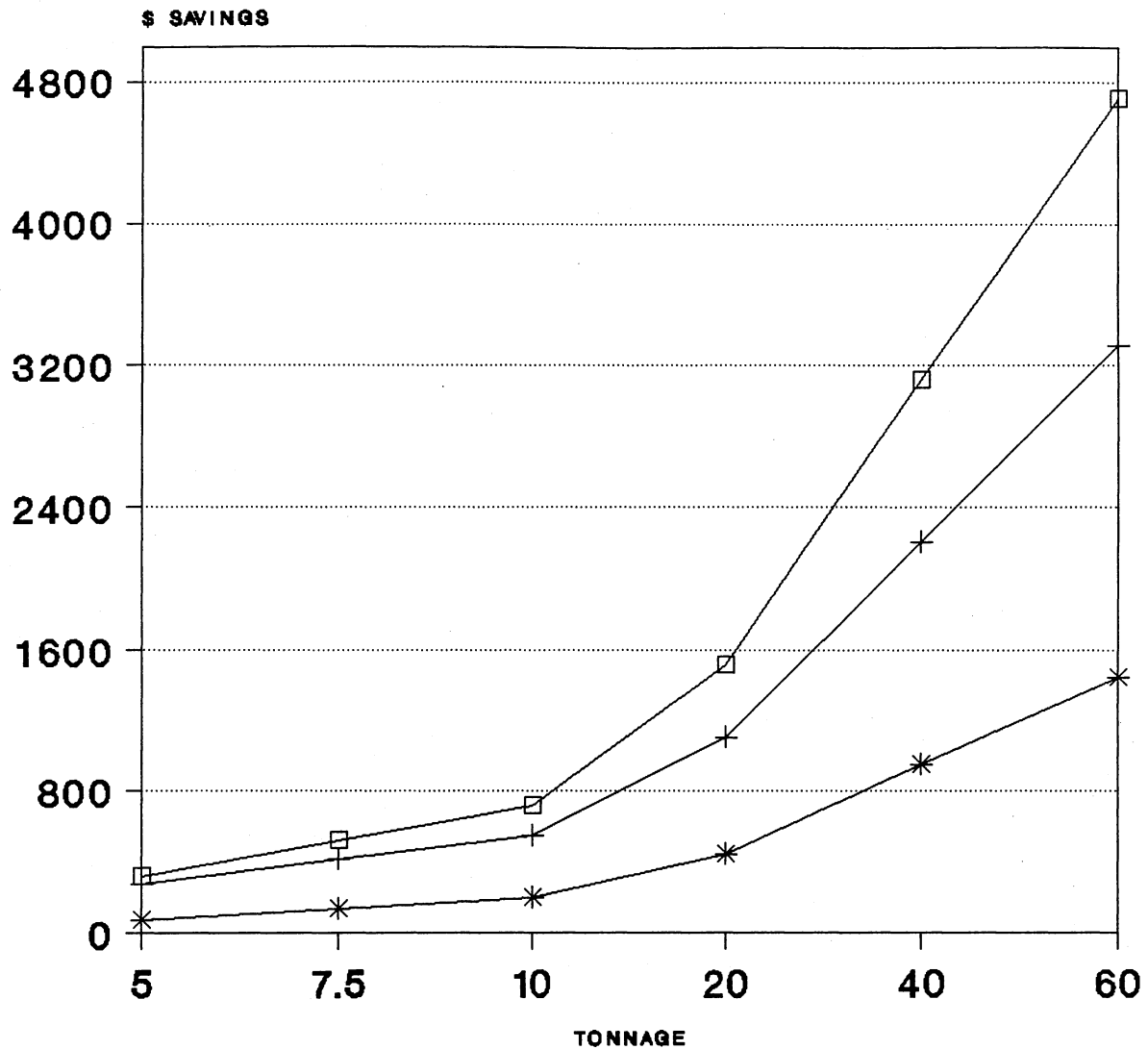
The next variable that was considered was the effect of the tonnage. In order to determine the variation of payback and savings due to the tonnage of the unit, six different tonnages were considered ranging from 5 to 60 tons. The other variables used

were a medium load profile and R-22 as the refrigerant. The detailed calculations are given in Appendix A.

As shown in Figure 14, the dollar savings increase for all cases as the tonnage increases. Note that the rate of increase grows as the tonnage increases to 60 tons. Figure 15 indicates the simple payback as it varies with tonnage. In all cases, the payback decreases as the tonnage increases. At about 20 tons, however, the payback flattens out at around 3 years. It is also interesting to note that the paybacks for the three cases (Hy-Save alone, desuperheating alone, and the two combined) are widely separated at lower tonnages. This wide separation indicates that The Hy-Save is not economically attractive when applied alone at lower tonnages. Desuperheating, however, is still attractive even at lower tonnages. When the two are combined, the payback is probably not attractive until a tonnage of about 10 tons is reached. The interesting thing to note, is that the lines for each case converge at 20 tons which indicates that there is very little difference above this size whether the technologies are applied alone or together.

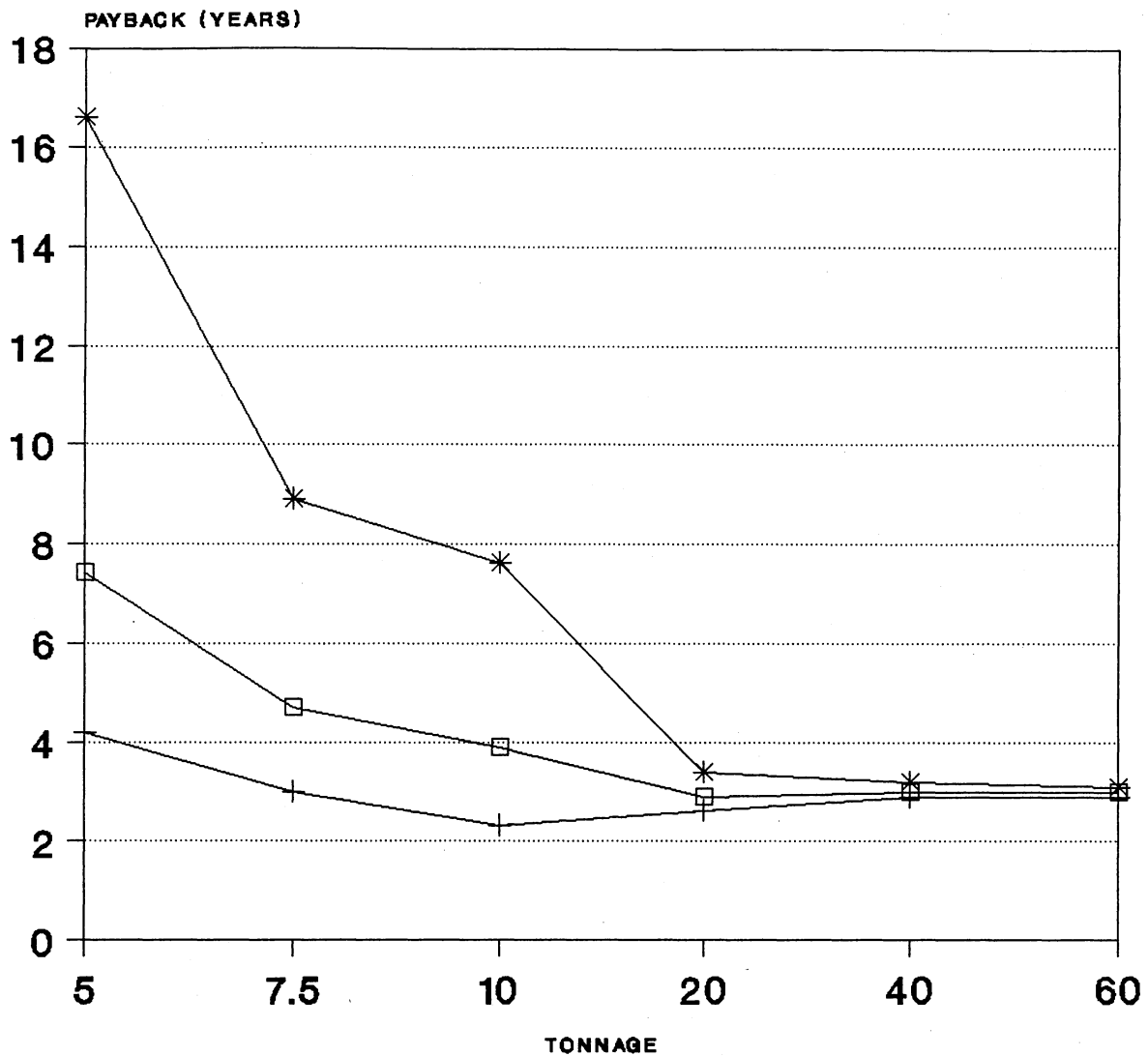
The final variable considered was the effect of different refrigerants. The refrigerants considered were R-22, R-12, and R-502 which are three of the most common ones for packaged units. The other variables used were a medium load profile and a 20 ton unit. The detailed calculations are given in Appendix A. The results of the calculations are plotted in Figures 16 and 17.

FIGURE 14
VARIATION WITH TONNAGE
\$ SAVINGS VS. TONNAGE (MEDIUM, R-22)



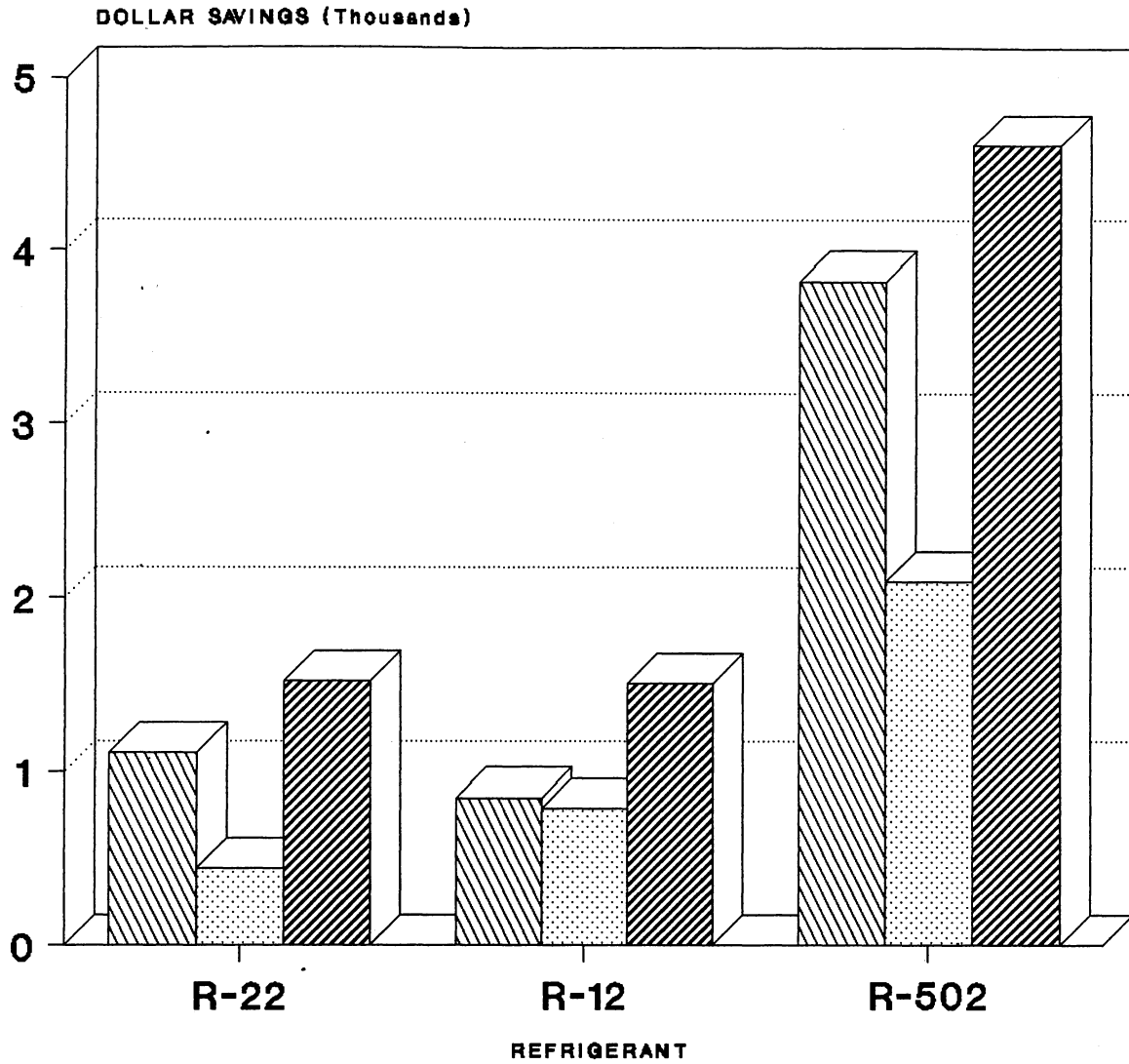
—+— DESUPERHEAT ONLY —*— HY-SAVE ONLY
—□— HY-SAVE & DESUPERHT.

FIGURE 15
VARIATION WITH TONNAGE
PAYBACK VS. TONNAGE (MEDIUM, R-22)



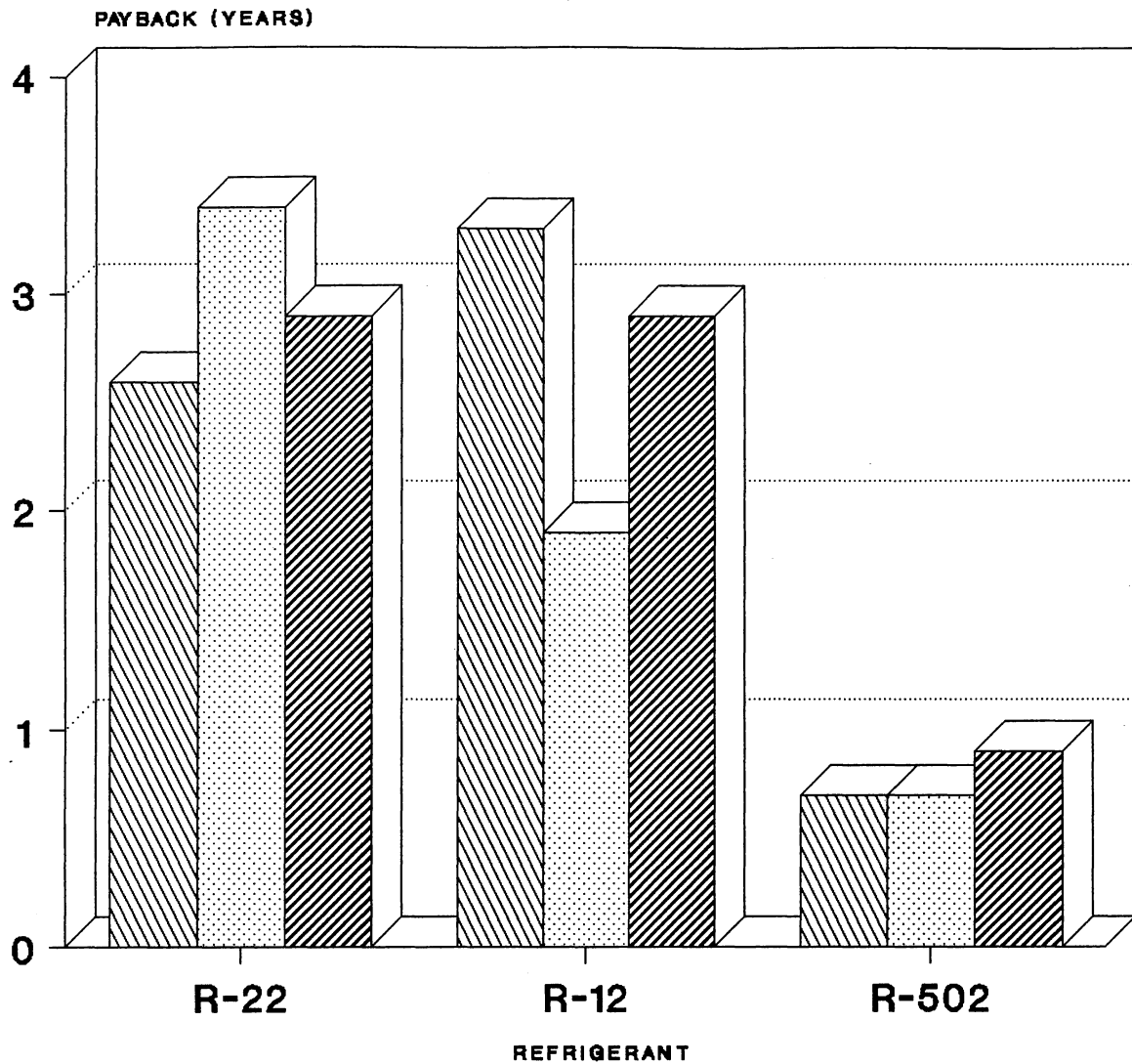
—+— DESUPERHEAT ONLY —*— HY-SAVE ONLY
—□— HY-SAVE & DESUPERHT.

FIGURE 16
VARIATION WITH REFRIGERANT
\$ SAVINGS VS. REFRIG. (MEDIUM, 20 TONS)



DESUPERHEAT ONLY HY-SAVE ONLY
HY-SAVE & DESUPERHT.

FIGURE 17
VARIATION WITH REFRIGERANT
PAYBACK VS. REFRIGERANT (MEDIUM, 20 TONS)



DESUPERHEAT ONLY HY-SAVE ONLY
HY-SAVE & DESUPERHT.

Figure 16 plots the dollar savings versus the refrigerant used for each case (desuperheater alone, Hy-Save alone, or both combined) and Figure 17 plots the associated paybacks versus refrigerant. These figures indicate that the best dollar savings and payback occur for R-502. For the Hy-Save applied alone, R- 502 is by far the best refrigerant, with R-22 performing the worst of the three. For desuperheating alone, R-502 gives the best savings while there is not much difference between R-22 and R-12. When looking at the savings and payback for the combined measures, R-502 results in savings of about \$4,500 and a payback of under 1 year while both R-12 and R-22 give similar results of \$1,500 and paybacks of about 3 years.

RECOMMENDATIONS AND AREAS FOR FURTHER RESEARCH

Most of the conclusions arrived at in this report are based on theoretical relationships and assumptions. One of the recommended areas for further research is to perform experiments with refrigeration equipment to obtain actual test data which could be used to refine the findings of this report. Such a test installation could utilized both a Hy- Save and a Desuperheater which could be valved in and out of the system as needed to simulate conditions with and without the interactive effects.

Another area for further research centers around the determination of the actual reduction in condensing pressure gained by the installation of a desuperheater. At the time that this report was

written, very little such data existed, and assumptions had to be made as to the reduction in condensing pressure. Although the tests described above may give some of the needed information, basic research in this area should be encouraged for organizations such as ASHRAE, ARI and the manufacturers of the desuperheaters themselves.

Finally, research should be conducted into the possibilities of the reduction of head pressure in ammonia refrigeration systems. This report did not address this issue specifically because of its focus on the liquid pressure amplifier, which cannot be applied to ammonia systems. In general, ammonia systems are more complex than freon systems and further research is necessary to determine what steps can be taken to reduce head pressure in these systems

CONCLUSIONS

The major conclusion derived from this study is that there are many applications where a desuperheater and Hy-Save can be installed successfully and economically together on the same machine. The installation of the two technologies together results in a decrease in the heat recovered by the desuperheater but, at the same time, increases the electrical savings of the Hy-Save. The net effect, however, is almost balanced, and the dollar savings which are available by installing both measures, is definitely better than just installing one of the measures alone.

Although not specifically addressed in this report, there will be some demand savings for installing desuperheating and the Hy-Save. For thermally light buildings, there will be small demand savings due to the operation of the desuperheater. For this case, however, operation of the Hy-Save will not result in demand savings. Thermally heavy buildings or process loads should result in much greater demand savings for the Hy-Save operation.

The results of a sensitivity analysis showed that the best savings and payback for the combined technologies favor tonnages of 20 tons and greater, medium or heavy load profiles, and R-502 as the refrigerant. It should be noted, however, that the results for R-12 and R-22 were very good in their own right.

Therefore, the installation of a desuperheater and a Hy-Save pump can result in increased savings and a very good payback for appropriate applications.

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APPENDIX A
SENSITIVITY CALCULATIONS

ECONOMIC SUMMARY

TONNAGE: 5 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$276/yr
Implementation Cost: \$1,148 (ht. exch. & pump installed)
Payback: 4.2 years

HY-SAVE ONLY

Annual Dollar Savings: \$72/yr
Implementation Cost: \$1,200 (1/25 hp pump installed)
Payback: 16.6 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$319/yr
Implementation Cost: \$2,348 (combined cost)
Payback: 7.4 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

LOAD PROFILE: MEDIUM

REFRIGERANT: R-22

BIN CALCULATION

Dry		Exist		NET REGRIG					POWER *		ENERGY
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	1,031.28	22.50	8.0	16
97	104	127	0.94	132.82	112.49	48.05	59.89	941.73	21.32	6.9	720
92	296	122	0.88	131.64	112.44	46.37	61.57	857.56	20.14	6.0	1,763
87	407	117	0.82	130.46	112.35	44.71	63.23	778.11	18.96	5.1	2,070
82	618	112	0.76	129.28	112.22	43.08	64.86	703.05	17.78	4.3	2,664
77	776	107	0.70	128.10	112.06	41.47	66.47	631.86	16.60	3.6	2,807
72	1009	105	0.64	127.63	111.99	40.83	67.11	572.19	16.13	3.2	3,211
67	747	105	0.58	127.63	111.99	40.83	67.11	518.55	16.13	2.9	2,154
62	642	105	0.52	127.63	111.99	40.83	67.11	464.91	16.13	2.6	1,660
57	601	105	0.46	127.63	111.99	40.83	67.11	411.27	16.13	2.3	1,375
52	684	105	0.40	127.63	111.99	40.83	67.11	357.62	16.13	2.0	1,360
47	569	105	0.34	127.63	111.99	40.83	67.11	303.98	16.13	1.7	962
42	667	105	0.28	127.63	111.99	40.83	67.11	250.34	16.13	1.4	929
37	621	105	0.22	127.63	111.99	40.83	67.11	196.69	16.13	1.1	679
32	504	105	0.16	127.63	111.99	40.83	67.11	143.05	16.13	0.8	401
27	229	105	0.10	127.63	111.99	40.83	67.11	89.41	16.13	0.5	114
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
8,476											22,885

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV.	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** \$
		Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB					ENERGY				
												CONSMPT KWH				
102	2	126	1.00	132.58	112.48	47.72	60.22	996.35	21.08	7.2	14	16	2	20.10	0.04	0.21
97	104	121	0.94	131.40	112.43	46.03	61.91	911.00	19.90	6.3	650	720	70	18.97	1.80	9.57
92	296	116	0.88	130.22	112.32	44.39	63.55	830.84	18.72	5.4	1,587	1,763	175	17.90	4.40	23.57
87	407	111	0.82	129.04	112.20	42.75	65.19	754.72	17.54	4.6	1,858	2,070	213	16.84	5.17	27.92
82	618	106	0.76	127.86	112.03	41.15	66.79	682.74	16.36	3.9	2,380	2,664	284	15.83	6.68	36.36
77	776	105	0.70	127.63	111.99	40.83	67.11	625.84	16.13	3.5	2,701	2,807	105	15.64	7.60	33.97
72	1009	105	0.64	127.63	111.99	40.83	67.11	572.19	16.13	3.2	3,211	3,211	0	15.64	9.03	36.12
67	747	105	0.58	127.63	111.99	40.83	67.11	518.55	16.13	2.9	2,154	2,154	0	15.64	6.06	24.23
62	642	105	0.52	127.63	111.99	40.83	67.11	464.91	16.13	2.6	1,660	1,660	0	15.64	4.67	18.67
57	601	105	0.46	127.63	111.99	40.83	67.11	411.27	16.13	2.3	1,375	1,375	0	15.64	3.87	15.46
52	684	105	0.40	127.63	111.99	40.83	67.11	357.62	16.13	2.0	1,360	1,360	0	15.64	3.83	15.30
47	569	105	0.34	127.63	111.99	40.83	67.11	303.98	16.13	1.7	962	962	0	15.64	2.71	10.82
42	667	105	0.28	127.63	111.99	40.83	67.11	250.34	16.13	1.4	929	929	0	15.64	2.61	10.45
37	621	105	0.22	127.63	111.99	40.83	67.11	196.69	16.13	1.1	679	679	0	15.64	1.91	7.64
32	504	105	0.16	127.63	111.99	40.83	67.11	143.05	16.13	0.8	401	401	0	15.64	1.13	4.51
27	229	105	0.10	127.63	111.99	40.83	67.11	89.41	16.13	0.5	114	114	0	15.64	0.32	1.28
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476											22,036	22,885	848		61.81	\$276

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry		Exist		NET REGRIG				POWER *		ENERGY		PREV. ENERGY	Add'l **	ELECT.	DOLLAR ***
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	SAVINGS
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	\$
102	2	132	1.00	134.00	112.51	49.76	58.18	1,031.28	22.50	8.0	16	16	0	0	0.00
97	104	127	0.94	132.82	112.49	48.05	59.89	941.73	21.32	6.9	720	720	0	0	0.00
92	296	122	0.88	131.64	112.44	46.37	61.57	857.56	20.14	6.0	1,763	1,763	0	0	0.00
87	407	117	0.82	130.46	112.35	44.71	63.23	778.11	18.96	5.1	2,070	2,070	0	0	0.00
82	618	112	0.76	129.28	112.22	43.08	64.86	703.05	17.78	4.3	2,664	2,664	0	0	0.00
77	776	107	0.70	128.10	112.06	41.47	66.47	631.86	16.60	3.6	2,807	2,807	0	0	0.00
72	1009	102	0.64	126.92	111.85	39.55	68.39	561.49	15.42	3.0	3,012	3,211	60	138	4.71
67	747	97	0.58	125.74	111.63	37.99	69.95	497.50	14.24	2.4	1,825	2,154	104	226	7.69
62	642	92	0.52	124.56	111.40	36.43	71.51	436.30	13.06	2.0	1,261	1,660	128	271	9.21
57	601	87	0.46	123.38	111.13	34.90	73.04	377.88	11.88	1.5	930	1,375	148	296	10.07
52	684	82	0.40	122.20	110.86	33.38	74.56	321.89	10.70	1.2	812	1,360	195	353	11.99
47	569	77	0.34	121.02	110.55	31.88	76.06	268.21	9.52	0.9	501	962	181	280	9.53
42	667	72	0.28	119.84	110.24	30.39	77.55	216.63	8.34	0.6	416	929	230	283	9.63
37	621	67	0.22	118.66	109.91	28.92	79.02	167.05	7.16	0.4	256	679	228	195	6.62
32	504	62	0.16	117.48	109.56	27.46	80.48	119.28	5.98	0.2	124	401	195	82	2.77
27	229	60	0.10	117.00	109.49	27.17	80.77	74.29	5.50	0.1	32	114	79	3	0.09
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
8,476											19,209	22,885	1,549	2,127	\$72

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG					POWER *		PREV. ENERGY	ENERGY	Add'l **	ELECT.	WASTE HT.	TOTAL	DOLLAR **	
		Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	AVAIL.	WASTE HT.	SAVINGS	
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	BTU/LB	MMBTU	\$	
102	2	126	1.00	132.58	112.48	47.72	60.22	996.35	21.08	7.2	14	16	0	2	20.10	0.04	0.21	
97	104	121	0.94	131.40	112.43	46.03	61.91	911.00	19.90	6.3	650	720	0	70	18.97	1.80	9.57	
92	296	116	0.88	130.22	112.32	44.39	63.55	830.84	18.72	5.4	1,587	1,763	0	175	17.90	4.40	23.57	
87	407	111	0.82	129.04	112.20	42.75	65.19	754.72	17.54	4.6	1,858	2,070	0	213	16.84	5.17	27.92	
82	618	106	0.76	127.86	112.03	41.15	66.79	682.74	16.36	3.9	2,380	2,664	0	284	15.83	6.68	36.36	
77	776	101	0.70	126.68	111.85	39.55	68.39	614.12	15.18	3.2	2,494	2,807	83	229	14.83	7.07	36.05	
72	1009	96	0.64	125.50	111.63	37.99	69.95	548.96	14.00	2.6	2,674	3,211	206	331	13.87	7.68	41.98	
67	747	91	0.58	124.32	111.40	36.43	71.51	486.65	12.82	2.2	1,607	2,154	206	341	12.92	4.70	30.38	
62	642	86	0.52	123.14	111.13	34.9	73.04	427.16	11.64	1.7	1,101	1,660	213	347	12.01	3.29	24.96	
57	601	81	0.46	121.96	110.86	33.38	74.56	370.17	10.46	1.3	802	1,375	225	347	11.10	2.47	21.67	
52	684	76	0.40	120.78	110.55	31.88	76.06	315.54	9.28	1.0	691	1,360	281	389	10.23	2.21	22.06	
47	569	71	0.34	119.60	110.24	30.39	77.55	263.06	8.10	0.7	418	962	250	294	9.36	1.40	15.59	
42	667	66	0.28	118.42	109.91	28.92	79.02	212.60	6.92	0.5	338	929	310	281	8.51	1.21	14.37	
37	621	61	0.22	117.24	109.56	27.46	80.48	164.02	5.74	0.3	202	679	301	176	7.68	0.78	9.13	
32	504	60	0.16	117.00	109.49	27.17	80.77	118.86	5.50	0.2	114	401	200	88	7.51	0.45	4.78	
27	229	60	0.10	117.00	109.49	27.17	80.77	74.29	5.50	0.1	32	114	72	10	7.51	0.13	0.84	
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
8,476												16,962	22,885	2,348	3,574		49.48	\$319

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 7.5 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$414/yr
Implementation Cost: \$1,245 (ht. exch. & pump installed)
Payback: 3.0 years

HY-SAVE ONLY

Annual Dollar Savings: \$135/yr
Implementation Cost: \$1,200 (1/25 hp pump installed)
Payback: 8.9 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$519/yr
Implementation Cost: \$2,445 (combined cost)
Payback: 4.7 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 7.5 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
<hr/>											
102	2	132	1.00	134.00	112.51	49.76	58.18	1,546.92	22.50	12.0	24
97	104	127	0.94	132.82	112.49	48.05	59.89	1,412.59	21.32	10.4	1,080
92	296	122	0.88	131.64	112.44	46.37	61.57	1,286.34	20.14	8.9	2,644
87	407	117	0.82	130.46	112.35	44.71	63.23	1,167.17	18.96	7.6	3,106
82	618	112	0.76	129.28	112.22	43.08	64.86	1,054.58	17.78	6.5	3,996
77	776	107	0.70	128.10	112.06	41.47	66.47	947.80	16.60	5.4	4,210
72	1009	105	0.64	127.63	111.99	40.83	67.11	858.29	16.13	4.8	4,817
67	747	105	0.58	127.63	111.99	40.83	67.11	777.83	16.13	4.3	3,232
62	642	105	0.52	127.63	111.99	40.83	67.11	697.36	16.13	3.9	2,490
57	601	105	0.46	127.63	111.99	40.83	67.11	616.90	16.13	3.4	2,062
52	684	105	0.40	127.63	111.99	40.83	67.11	536.43	16.13	3.0	2,041
47	569	105	0.34	127.63	111.99	40.83	67.11	455.97	16.13	2.5	1,443
42	667	105	0.28	127.63	111.99	40.83	67.11	375.50	16.13	2.1	1,393
37	621	105	0.22	127.63	111.99	40.83	67.11	295.04	16.13	1.6	1,019
32	504	105	0.16	127.63	111.99	40.83	67.11	214.57	16.13	1.2	601
27	229	105	0.10	127.63	111.99	40.83	67.11	134.11	16.13	0.7	171
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
<hr/>											
8,476											34,327

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 7.5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV.	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** \$
		Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB					ENERGY				
												CONSMPT KWH				
102	2	126	1.00	132.58	112.48	47.72	60.22	1,494.52	21.08	10.9	22	24	2	20.10	0.06	0.32
97	104	121	0.94	131.40	112.43	46.03	61.91	1,366.50	19.90	9.4	975	1,080	105	18.97	2.70	14.35
92	296	116	0.88	130.22	112.32	44.39	63.55	1,246.26	18.72	8.0	2,381	2,644	263	17.90	6.60	35.35
87	407	111	0.82	129.04	112.20	42.75	65.19	1,132.08	17.54	6.8	2,787	3,106	319	16.84	7.76	41.88
82	618	106	0.76	127.86	112.03	41.15	66.79	1,024.11	16.36	5.8	3,570	3,996	425	15.83	10.02	54.54
77	776	105	0.70	127.63	111.99	40.83	67.11	938.76	16.13	5.2	4,052	4,210	158	15.64	11.39	50.95
72	1009	105	0.64	127.63	111.99	40.83	67.11	858.29	16.13	4.8	4,817	4,817	0	15.64	13.54	54.18
67	747	105	0.58	127.63	111.99	40.83	67.11	777.83	16.13	4.3	3,232	3,232	0	15.64	9.09	36.35
62	642	105	0.52	127.63	111.99	40.83	67.11	697.36	16.13	3.9	2,490	2,490	0	15.64	7.00	28.01
57	601	105	0.46	127.63	111.99	40.83	67.11	616.90	16.13	3.4	2,062	2,062	0	15.64	5.80	23.19
52	684	105	0.40	127.63	111.99	40.83	67.11	536.43	16.13	3.0	2,041	2,041	0	15.64	5.74	22.95
47	569	105	0.34	127.63	111.99	40.83	67.11	455.97	16.13	2.5	1,443	1,443	0	15.64	4.06	16.23
42	667	105	0.28	127.63	111.99	40.83	67.11	375.50	16.13	2.1	1,393	1,393	0	15.64	3.92	15.67
37	621	105	0.22	127.63	111.99	40.83	67.11	295.04	16.13	1.6	1,019	1,019	0	15.64	2.87	11.46
32	504	105	0.16	127.63	111.99	40.83	67.11	214.57	16.13	1.2	601	601	0	15.64	1.69	6.77
27	229	105	0.10	127.63	111.99	40.83	67.11	134.11	16.13	0.7	171	171	0	15.64	0.48	1.92
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476											33,054	34,327	1,273		92.71	\$414

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 7.5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours	Exist		NET REGRIG						POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV.	Add'l ** Fan KWH	ELECT. SAVINGS KWH	DOLLAR *** SAVINGS \$	
		Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	ENERGY							
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB			CONSMPT KWH				
102	2	132	1.00	134.00	112.51	49.76	58.18	1,546.92	22.50	12.0	24	24	0	0	0.00	
97	104	127	0.94	132.82	112.49	48.05	59.89	1,412.59	21.32	10.4	1,080	1,080	0	0	0.00	
92	296	122	0.88	131.64	112.44	46.37	61.57	1,286.34	20.14	8.9	2,644	2,644	0	0	0.00	
87	407	117	0.82	130.46	112.35	44.71	63.23	1,167.17	18.96	7.6	3,106	3,106	0	0	0.00	
82	618	112	0.76	129.28	112.22	43.08	64.86	1,054.58	17.78	6.5	3,996	3,996	0	0	0.00	
77	776	107	0.70	128.10	112.06	41.47	66.47	947.80	16.60	5.4	4,210	4,210	0	0	0.00	
72	1009	102	0.64	126.92	111.85	39.55	68.39	842.23	15.42	4.5	4,518	4,817	60	238	8.09	
67	747	97	0.58	125.74	111.63	37.99	69.95	746.25	14.24	3.7	2,737	3,232	104	391	13.29	
62	642	92	0.52	124.56	111.40	36.43	71.51	654.45	13.06	2.9	1,892	2,490	128	470	15.99	
57	601	87	0.46	123.38	111.13	34.90	73.04	566.81	11.88	2.3	1,395	2,062	148	518	17.62	
52	684	82	0.40	122.20	110.86	33.38	74.56	482.83	10.70	1.8	1,218	2,041	195	627	21.31	
47	569	77	0.34	121.02	110.55	31.88	76.06	402.31	9.52	1.3	751	1,443	181	511	17.36	
42	667	72	0.28	119.84	110.24	30.39	77.55	324.95	8.34	0.9	623	1,393	230	540	18.35	
37	621	67	0.22	118.66	109.91	28.92	79.02	250.57	7.16	0.6	384	1,019	228	406	13.82	
32	504	62	0.16	117.48	109.56	27.46	80.48	178.93	5.98	0.4	186	601	195	220	7.48	
27	229	60	0.10	117.00	109.49	27.17	80.77	111.43	5.50	0.2	48	171	79	43	1.47	
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
8,476												28,813	34,327	1,549	3,964	\$135

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 7.5 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *	ENERGY	PREV. ENERGY	Add'l **	ELECT.	WASTE HT.	TOTAL	DOLLAR **
		Cond	LOAD	H1	H1a	H3	EFFECT			CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	AVAIL.	WASTE HT.	SAVINGS
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB				KWH	KWH	KWH	KWH	KWH	BTU/LB	MMBTU
102	2	126	1.00	132.58	112.48	47.72	60.22	1,494.52	21.08	10.9	22	24	0	2	20.10	0.06	0.32
97	104	121	0.94	131.40	112.43	46.03	61.91	1,366.50	19.90	9.4	975	1,080	0	105	18.97	2.70	14.35
92	296	116	0.88	130.22	112.32	44.39	63.55	1,246.26	18.72	8.0	2,381	2,644	0	263	17.90	6.60	35.35
87	407	111	0.82	129.04	112.20	42.75	65.19	1,132.08	17.54	6.8	2,787	3,106	0	319	16.84	7.76	41.88
82	618	106	0.76	127.86	112.03	41.15	66.79	1,024.11	16.36	5.8	3,570	3,996	0	425	15.83	10.02	54.54
77	776	101	0.70	126.68	111.85	39.55	68.39	921.19	15.18	4.8	3,742	4,210	83	385	14.83	10.60	55.50
72	1009	96	0.64	125.50	111.63	37.99	69.95	823.45	14.00	4.0	4,011	4,817	206	599	13.87	11.52	66.47
67	747	91	0.58	124.32	111.40	36.43	71.51	729.97	12.82	3.2	2,410	3,232	206	615	12.92	7.05	49.08
62	642	86	0.52	123.14	111.13	34.9	73.04	640.74	11.64	2.6	1,651	2,490	213	626	12.01	4.94	41.05
57	601	81	0.46	121.96	110.86	33.38	74.56	555.26	10.46	2.0	1,204	2,062	225	633	11.10	3.70	36.34
52	684	76	0.40	120.78	110.55	31.88	76.06	473.31	9.28	1.5	1,036	2,041	281	724	10.23	3.31	37.87
47	569	71	0.34	119.60	110.24	30.39	77.55	394.58	8.10	1.1	627	1,443	250	566	9.36	2.10	27.64
42	667	66	0.28	118.42	109.91	28.92	79.02	318.91	6.92	0.8	508	1,393	310	576	8.51	1.81	26.82
37	621	61	0.22	117.24	109.56	27.46	80.48	246.02	5.74	0.5	302	1,019	301	415	7.68	1.17	18.81
32	504	60	0.16	117.00	109.49	27.17	80.77	178.28	5.50	0.3	170	601	200	231	7.51	0.67	10.56
27	229	60	0.10	117.00	109.49	27.17	80.77	111.43	5.50	0.2	48	171	72	50	7.51	0.19	2.48
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
8,476											25,444	34,327	2,348	6,535		74.22	\$519

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 10 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$552/yr
Implementation Cost: \$1,283 (ht. exch. & pump installed)
Payback: 2.3 years

HY-SAVE ONLY

Annual Dollar Savings: \$197/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 7.6 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$719/yr
Implementation Cost: \$2,783 (combined cost)
Payback: 3.9 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 10 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG						POWER *	ENERGY		
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	2,062.56	22.50	16.0	32
97	104	127	0.94	132.82	112.49	48.05	59.89	1,883.45	21.32	13.8	1,440
92	296	122	0.88	131.64	112.44	46.37	61.57	1,715.12	20.14	11.9	3,525
87	407	117	0.82	130.46	112.35	44.71	63.23	1,556.22	18.96	10.2	4,141
82	618	112	0.76	129.28	112.22	43.08	64.86	1,406.11	17.78	8.6	5,327
77	776	107	0.70	128.10	112.06	41.47	66.47	1,263.73	16.60	7.2	5,613
72	1009	105	0.64	127.63	111.99	40.83	67.11	1,144.39	16.13	6.4	6,422
67	747	105	0.58	127.63	111.99	40.83	67.11	1,037.10	16.13	5.8	4,309
62	642	105	0.52	127.63	111.99	40.83	67.11	929.82	16.13	5.2	3,320
57	601	105	0.46	127.63	111.99	40.83	67.11	822.53	16.13	4.6	2,749
52	684	105	0.40	127.63	111.99	40.83	67.11	715.24	16.13	4.0	2,721
47	569	105	0.34	127.63	111.99	40.83	67.11	607.96	16.13	3.4	1,924
42	667	105	0.28	127.63	111.99	40.83	67.11	500.67	16.13	2.8	1,857
37	621	105	0.22	127.63	111.99	40.83	67.11	393.38	16.13	2.2	1,359
32	504	105	0.16	127.63	111.99	40.83	67.11	286.10	16.13	1.6	802
27	229	105	0.10	127.63	111.99	40.83	67.11	178.81	16.13	1.0	228
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
8,476											45,769

* Motor effeciency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 10 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *	ENERGY	PREV. ENERGY	ELECT.	WASTE HT.	TOTAL	DOLLAR **
		Cond	LOAD	H1	H1a	H3	EFFECT			CONSMPT	CONSMPT	CONSMPT	SAVINGS	AVAIL.	WASTE HT.	SAVINGS
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB				KWH	KWH	KWH	KWH	BTU/LB	MMBTU
102	2	126	1.00	132.58	112.48	47.72	60.22	1,992.69	21.08	14.5	29	32	3	20.10	0.08	0.42
97	104	121	0.94	131.40	112.43	46.03	61.91	1,822.00	19.90	12.5	1,300	1,440	140	18.97	3.59	19.13
92	296	116	0.88	130.22	112.32	44.39	63.55	1,661.68	18.72	10.7	3,175	3,525	351	17.90	8.80	47.14
87	407	111	0.82	129.04	112.20	42.75	65.19	1,509.43	17.54	9.1	3,715	4,141	425	16.84	10.35	55.84
82	618	106	0.76	127.86	112.03	41.15	66.79	1,365.47	16.36	7.7	4,760	5,327	567	15.83	13.36	72.72
77	776	105	0.70	127.63	111.99	40.83	67.11	1,251.68	16.13	7.0	5,402	5,613	211	15.64	15.19	67.94
72	1009	105	0.64	127.63	111.99	40.83	67.11	1,144.39	16.13	6.4	6,422	6,422	0	15.64	18.06	72.24
67	747	105	0.58	127.63	111.99	40.83	67.11	1,037.10	16.13	5.8	4,309	4,309	0	15.64	12.12	48.47
62	642	105	0.52	127.63	111.99	40.83	67.11	929.82	16.13	5.2	3,320	3,320	0	15.64	9.34	37.34
57	601	105	0.46	127.63	111.99	40.83	67.11	822.53	16.13	4.6	2,749	2,749	0	15.64	7.73	30.93
52	684	105	0.40	127.63	111.99	40.83	67.11	715.24	16.13	4.0	2,721	2,721	0	15.64	7.65	30.61
47	569	105	0.34	127.63	111.99	40.83	67.11	607.96	16.13	3.4	1,924	1,924	0	15.64	5.41	21.64
42	667	105	0.28	127.63	111.99	40.83	67.11	500.67	16.13	2.8	1,857	1,857	0	15.64	5.22	20.89
37	621	105	0.22	127.63	111.99	40.83	67.11	393.38	16.13	2.2	1,359	1,359	0	15.64	3.82	15.28
32	504	105	0.16	127.63	111.99	40.83	67.11	286.10	16.13	1.6	802	802	0	15.64	2.26	9.02
27	229	105	0.10	127.63	111.99	40.83	67.11	178.81	16.13	1.0	228	228	0	15.64	0.64	2.56
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476											44,072	45,769	1,697		123.62	\$552

* Motor effeciency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 10 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *	ENERGY	PREV. ENERGY	Add'l **	ELECT.	DOLLAR ***
		Cond	LOAD	H1	H1a	H3	EFFECT			CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	SAVINGS
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB				KWH	KWH	KWH	KWH	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	2,062.56	22.50	16.0	32	32	0	0	0.00
97	104	127	0.94	132.82	112.49	48.05	59.89	1,883.45	21.32	13.8	1,440	1,440	0	0	0.00
92	296	122	0.88	131.64	112.44	46.37	61.57	1,715.12	20.14	11.9	3,525	3,525	0	0	0.00
87	407	117	0.82	130.46	112.35	44.71	63.23	1,556.22	18.96	10.2	4,141	4,141	0	0	0.00
82	618	112	0.76	129.28	112.22	43.08	64.86	1,406.11	17.78	8.6	5,327	5,327	0	0	0.00
77	776	107	0.70	128.10	112.06	41.47	66.47	1,263.73	16.60	7.2	5,613	5,613	0	0	0.00
72	1009	102	0.64	126.92	111.85	39.55	68.39	1,122.97	15.42	6.0	6,024	6,422	60	337	11.47
67	747	97	0.58	125.74	111.63	37.99	69.95	995.00	14.24	4.9	3,649	4,309	104	556	18.90
62	642	92	0.52	124.56	111.40	36.43	71.51	872.61	13.06	3.9	2,523	3,320	128	670	22.76
57	601	87	0.46	123.38	111.13	34.90	73.04	755.75	11.88	3.1	1,861	2,749	148	740	25.18
52	684	82	0.40	122.20	110.86	33.38	74.56	643.78	10.70	2.4	1,625	2,721	195	901	30.63
47	569	77	0.34	121.02	110.55	31.88	76.06	536.42	9.52	1.8	1,002	1,924	181	741	25.20
42	667	72	0.28	119.84	110.24	30.39	77.55	433.27	8.34	1.2	831	1,857	230	796	27.07
37	621	67	0.22	118.66	109.91	28.92	79.02	334.09	7.16	0.8	512	1,359	228	618	21.01
32	504	62	0.16	117.48	109.56	27.46	80.48	238.57	5.98	0.5	248	802	195	359	12.19
27	229	60	0.10	117.00	109.49	27.17	80.77	148.57	5.50	0.3	65	228	79	84	2.86
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
8,476											38,418	45,769	1,549	5,802	\$197

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 10 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV.	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
		Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB					ENERGY					
												CONSMPT KWH					
102	2	126	1.00	132.58	112.48	47.72	60.22	1,992.69	21.08	14.5	29	32	0	3	20.10	0.08	0.42
97	104	121	0.94	131.40	112.43	46.03	61.91	1,822.00	19.90	12.5	1,300	1,440	0	140	18.97	3.59	19.13
92	296	116	0.88	130.22	112.32	44.39	63.55	1,661.68	18.72	10.7	3,175	3,525	0	351	17.90	8.80	47.14
87	407	111	0.82	129.04	112.20	42.75	65.19	1,509.43	17.54	9.1	3,715	4,141	0	425	16.84	10.35	55.84
82	618	106	0.76	127.86	112.03	41.15	66.79	1,365.47	16.36	7.7	4,760	5,327	0	567	15.83	13.36	72.72
77	776	101	0.70	126.68	111.85	39.55	68.39	1,228.25	15.18	6.4	4,989	5,613	83	541	14.83	14.13	74.94
72	1009	96	0.64	125.50	111.63	37.99	69.95	1,097.93	14.00	5.3	5,348	6,422	206	868	13.87	15.37	90.97
67	747	91	0.58	124.32	111.40	36.43	71.51	973.29	12.82	4.3	3,214	4,309	206	888	12.92	9.39	67.78
62	642	86	0.52	123.14	111.13	34.9	73.04	854.33	11.64	3.4	2,201	3,320	213	906	12.01	6.59	57.15
57	601	81	0.46	121.96	110.86	33.38	74.56	740.34	10.46	2.7	1,605	2,749	225	919	11.10	4.94	51.01
52	684	76	0.40	120.78	110.55	31.88	76.06	631.08	9.28	2.0	1,381	2,721	281	1,059	10.23	4.42	53.67
47	569	71	0.34	119.60	110.24	30.39	77.55	526.11	8.10	1.5	836	1,924	250	838	9.36	2.80	39.69
42	667	66	0.28	118.42	109.91	28.92	79.02	425.21	6.92	1.0	677	1,857	310	871	8.51	2.41	39.27
37	621	61	0.22	117.24	109.56	27.46	80.48	328.03	5.74	0.6	403	1,359	301	654	7.68	1.56	28.50
32	504	60	0.16	117.00	109.49	27.17	80.77	237.71	5.50	0.5	227	802	200	375	7.51	0.90	16.35
27	229	60	0.10	117.00	109.49	27.17	80.77	148.57	5.50	0.3	65	228	72	91	7.51	0.26	4.12
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
8,476											33,925	45,769	2,348	9,497		98.95	\$719

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 40 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$2,209/yr
Implementation Cost: \$6,495 (ht. exch. & pump installed)
Payback: 2.9 years

HY-SAVE ONLY

Annual Dollar Savings: \$947/yr
Implementation Cost: \$3,000 (two 1/5 hp pumps installed)
Payback: 3.2 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$3,114/yr
Implementation Cost: \$9,495 (combined cost)
Payback: 3.0 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 40 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	8,250.26	22.50	64.0	128
97	104	127	0.94	132.82	112.49	48.05	59.89	7,533.81	21.32	55.4	5,760
92	296	122	0.88	131.64	112.44	46.37	61.57	6,860.48	20.14	47.6	14,102
87	407	117	0.82	130.46	112.35	44.71	63.23	6,224.89	18.96	40.7	16,563
82	618	112	0.76	129.28	112.22	43.08	64.86	5,624.42	17.78	34.5	21,309
77	776	107	0.70	128.10	112.06	41.47	66.47	5,054.91	16.60	28.9	22,452
72	1009	105	0.64	127.63	111.99	40.83	67.11	4,577.56	16.13	25.5	25,688
67	747	105	0.58	127.63	111.99	40.83	67.11	4,148.41	16.13	23.1	17,235
62	642	105	0.52	127.63	111.99	40.83	67.11	3,719.27	16.13	20.7	13,280
57	601	105	0.46	127.63	111.99	40.83	67.11	3,290.12	16.13	18.3	10,997
52	684	105	0.40	127.63	111.99	40.83	67.11	2,860.97	16.13	15.9	10,884
47	569	105	0.34	127.63	111.99	40.83	67.11	2,431.83	16.13	13.5	7,696
42	667	105	0.28	127.63	111.99	40.83	67.11	2,002.68	16.13	11.1	7,429
37	621	105	0.22	127.63	111.99	40.83	67.11	1,573.54	16.13	8.8	5,435
32	504	105	0.16	127.63	111.99	40.83	67.11	1,144.39	16.13	6.4	3,208
27	229	105	0.10	127.63	111.99	40.83	67.11	715.24	16.13	4.0	911
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
8,476											183,077

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 40 TONS
REFRIGERANT: R-22

GAS COST: \$3.20/MCF
ELECT. COST: \$0.034/KWH

LOAD PROFILE: MEDIUM

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV.	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
		Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB					ENERGY				
												CONSMPT KWH				
102	2	126	1.00	132.58	112.48	47.72	60.22	7,970.77	21.08	57.9	116	128	12	20.10	0.32	1.69
97	104	121	0.94	131.40	112.43	46.03	61.91	7,288.00	19.90	50.0	5,201	5,760	559	18.97	14.38	76.52
92	296	116	0.88	130.22	112.32	44.39	63.55	6,646.73	18.72	42.9	12,699	14,102	1,403	17.90	35.22	188.56
87	407	111	0.82	129.04	112.20	42.75	65.19	6,037.74	17.54	36.5	14,862	16,563	1,701	16.84	41.38	223.37
82	618	106	0.76	127.86	112.03	41.15	66.79	5,461.90	16.36	30.8	19,041	21,309	2,268	15.83	53.43	290.86
77	776	105	0.70	127.63	111.99	40.83	67.11	5,006.71	16.13	27.8	21,608	22,452	844	15.64	60.76	271.75
72	1009	105	0.64	127.63	111.99	40.83	67.11	4,577.56	16.13	25.5	25,688	25,688	0	15.64	72.24	288.95
67	747	105	0.58	127.63	111.99	40.83	67.11	4,148.41	16.13	23.1	17,235	17,235	0	15.64	48.47	193.86
62	642	105	0.52	127.63	111.99	40.83	67.11	3,719.27	16.13	20.7	13,280	13,280	0	15.64	37.34	149.38
57	601	105	0.46	127.63	111.99	40.83	67.11	3,290.12	16.13	18.3	10,997	10,997	0	15.64	30.93	123.70
52	684	105	0.40	127.63	111.99	40.83	67.11	2,860.97	16.13	15.9	10,884	10,884	0	15.64	30.61	122.42
47	569	105	0.34	127.63	111.99	40.83	67.11	2,431.83	16.13	13.5	7,696	7,696	0	15.64	21.64	86.56
42	667	105	0.28	127.63	111.99	40.83	67.11	2,002.68	16.13	11.1	7,429	7,429	0	15.64	20.89	83.57
37	621	105	0.22	127.63	111.99	40.83	67.11	1,573.54	16.13	8.8	5,435	5,435	0	15.64	15.28	61.13
32	504	105	0.16	127.63	111.99	40.83	67.11	1,144.39	16.13	6.4	3,208	3,208	0	15.64	9.02	36.08
27	229	105	0.10	127.63	111.99	40.83	67.11	715.24	16.13	4.0	911	911	0	15.64	2.56	10.25
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476											176,289	183,077	6,787		494.47	\$2,209

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 40 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG EFFECT BTU/LB	REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	Add'l ** Fan KWH	ELECT. SAVINGS KWH	DOLLAR *** SAVINGS \$
												KWH			
102	2	132	1.00	134.00	112.51	49.76	58.18	8,250.26	22.50	64.0	128	128	0	0	0.00
97	104	127	0.94	132.82	112.49	48.05	59.89	7,533.81	21.32	55.4	5,760	5,760	0	0	0.00
92	296	122	0.88	131.64	112.44	46.37	61.57	6,860.48	20.14	47.6	14,102	14,102	0	0	0.00
87	407	117	0.82	130.46	112.35	44.71	63.23	6,224.89	18.96	40.7	16,563	16,563	0	0	0.00
82	618	112	0.76	129.28	112.22	43.08	64.86	5,624.42	17.78	34.5	21,309	21,309	0	0	0.00
77	776	107	0.70	128.10	112.06	41.47	66.47	5,054.91	16.60	28.9	22,452	22,452	0	0	0.00
72	1009	102	0.64	126.92	111.85	39.55	68.39	4,491.88	15.42	23.9	24,098	25,688	60	1,530	52.02
67	747	97	0.58	125.74	111.63	37.99	69.95	3,979.99	14.24	19.5	14,598	17,235	104	2,534	86.15
62	642	92	0.52	124.56	111.40	36.43	71.51	3,490.42	13.06	15.7	10,091	13,280	128	3,061	104.09
57	601	87	0.46	123.38	111.13	34.90	73.04	3,023.00	11.88	12.4	7,442	10,997	148	3,407	115.84
52	684	82	0.40	122.20	110.86	33.38	74.56	2,575.11	10.70	9.5	6,498	10,884	195	4,190	142.46
47	569	77	0.34	121.02	110.55	31.88	76.06	2,145.67	9.52	7.0	4,008	7,696	181	3,507	119.25
42	667	72	0.28	119.84	110.24	30.39	77.55	1,733.08	8.34	5.0	3,324	7,429	230	3,875	131.75
37	621	67	0.22	118.66	109.91	28.92	79.02	1,336.37	7.16	3.3	2,049	5,435	228	3,157	107.35
32	504	62	0.16	117.48	109.56	27.46	80.48	954.27	5.98	2.0	992	3,208	195	2,021	68.70
27	229	60	0.10	117.00	109.49	27.17	80.77	594.28	5.50	1.1	258	911	79	574	19.51
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
8,476											153,671	183,077	1,549	27,856	\$947

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 40 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG EFFECT BTU/LB	REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
												KWH					
102	2	126	1.00	132.58	112.48	47.72	60.22	7,970.77	21.08	57.9	116	128	0	12	20.10	0.32	1.69
97	104	121	0.94	131.40	112.43	46.03	61.91	7,288.00	19.90	50.0	5,201	5,760	0	559	18.97	14.38	76.52
92	296	116	0.88	130.22	112.32	44.39	63.55	6,646.73	18.72	42.9	12,699	14,102	0	1,403	17.90	35.22	188.56
87	407	111	0.82	129.04	112.20	42.75	65.19	6,037.74	17.54	36.5	14,862	16,563	0	1,701	16.84	41.38	223.37
82	618	106	0.76	127.86	112.03	41.15	66.79	5,461.90	16.36	30.8	19,041	21,309	0	2,268	15.83	53.43	290.86
77	776	101	0.70	126.68	111.85	39.55	68.39	4,913.00	15.18	25.7	19,955	22,452	83	2,414	14.83	56.54	308.23
72	1009	96	0.64	125.50	111.63	37.99	69.95	4,391.71	14.00	21.2	21,391	25,688	206	4,091	13.87	61.46	384.94
67	747	91	0.58	124.32	111.40	36.43	71.51	3,893.16	12.82	17.2	12,855	17,235	206	4,173	12.92	37.57	292.18
62	642	86	0.52	123.14	111.13	34.9	73.04	3,417.31	11.64	13.7	8,805	13,280	213	4,262	12.01	26.35	250.30
57	601	81	0.46	121.96	110.86	33.38	74.56	2,961.37	10.46	10.7	6,419	10,997	225	4,353	11.10	19.76	227.03
52	684	76	0.40	120.78	110.55	31.88	76.06	2,524.32	9.28	8.1	5,525	10,884	281	5,078	10.23	17.66	243.31
47	569	71	0.34	119.60	110.24	30.39	77.55	2,104.45	8.10	5.9	3,344	7,696	250	4,101	9.36	11.21	184.28
42	667	66	0.28	118.42	109.91	28.92	79.02	1,700.84	6.92	4.1	2,707	7,429	310	4,413	8.51	9.65	188.65
37	621	61	0.22	117.24	109.56	27.46	80.48	1,312.13	5.74	2.6	1,613	5,435	301	3,521	7.68	6.26	144.73
32	504	60	0.16	117.00	109.49	27.17	80.77	950.85	5.50	1.8	909	3,208	200	2,099	7.51	3.60	85.77
27	229	60	0.10	117.00	109.49	27.17	80.77	594.28	5.50	1.1	258	911	72	581	7.51	1.02	23.84
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
8,476											135,700	183,077	2,348	45,029		395.81	\$3,114

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 60 TONS
REFRIGERANT: R-22

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$3,313/yr
Implementation Cost: \$9,645 (ht. exch. & pump installed)
Payback: 2.9 years

HY-SAVE ONLY

Annual Dollar Savings: \$1,447/yr
Implementation Cost: \$4,500 (3- 1/5 hp pumps installed)
Payback: 3.1 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$4,711/yr
Implementation Cost: \$14,145 (combined cost)
Payback: 3.0 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 60 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
<hr/>											
102	2	132	1.00	134.00	112.51	49.76	58.18	12,375.39	22.50	96.0	192
97	104	127	0.94	132.82	112.49	48.05	59.89	11,300.72	21.32	83.1	8,640
92	296	122	0.88	131.64	112.44	46.37	61.57	10,290.73	20.14	71.5	21,153
87	407	117	0.82	130.46	112.35	44.71	63.23	9,337.34	18.96	61.0	24,844
82	618	112	0.76	129.28	112.22	43.08	64.86	8,436.63	17.78	51.7	31,964
77	776	107	0.70	128.10	112.06	41.47	66.47	7,582.37	16.60	43.4	33,678
72	1009	105	0.64	127.63	111.99	40.83	67.11	6,866.34	16.13	38.2	38,532
67	747	105	0.58	127.63	111.99	40.83	67.11	6,222.62	16.13	34.6	25,852
62	642	105	0.52	127.63	111.99	40.83	67.11	5,578.90	16.13	31.0	19,920
57	601	105	0.46	127.63	111.99	40.83	67.11	4,935.18	16.13	27.4	16,496
52	684	105	0.40	127.63	111.99	40.83	67.11	4,291.46	16.13	23.9	16,326
47	569	105	0.34	127.63	111.99	40.83	67.11	3,647.74	16.13	20.3	11,544
42	667	105	0.28	127.63	111.99	40.83	67.11	3,004.02	16.13	16.7	11,144
37	621	105	0.22	127.63	111.99	40.83	67.11	2,360.30	16.13	13.1	8,152
32	504	105	0.16	127.63	111.99	40.83	67.11	1,716.58	16.13	9.5	4,812
27	229	105	0.10	127.63	111.99	40.83	67.11	1,072.87	16.13	6.0	1,366
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
<hr/>											
8,476											274,615

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 60 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry		Exist		NET REGRIG				POWER *		ENERGY		PREV. ENERGY	ELECT.	WASTE HT.	TOTAL	DOLLAR **
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	SAVINGS	AVAIL.	WASTE HT.	SAVINGS
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	BTU/LB	MMBTU	\$
102	2	126	1.00	132.58	112.48	47.72	60.22	11,956.16	21.08	86.9	174	192	18	20.10	0.48	2.54
97	104	121	0.94	131.40	112.43	46.03	61.91	10,932.00	19.90	75.0	7,801	8,640	839	18.97	21.57	114.78
92	296	116	0.88	130.22	112.32	44.39	63.55	9,970.10	18.72	64.4	19,049	21,153	2,104	17.90	52.83	282.84
87	407	111	0.82	129.04	112.20	42.75	65.19	9,056.60	17.54	54.8	22,293	24,844	2,552	16.84	62.07	335.05
82	618	106	0.76	127.86	112.03	41.15	66.79	8,192.84	16.36	46.2	28,561	31,964	3,403	15.83	80.15	436.29
77	776	105	0.70	127.63	111.99	40.83	67.11	7,510.06	16.13	41.8	32,412	33,678	1,266	15.64	91.15	407.62
72	1009	105	0.64	127.63	111.99	40.83	67.11	6,866.34	16.13	38.2	38,532	38,532	0	15.64	108.36	433.42
67	747	105	0.58	127.63	111.99	40.83	67.11	6,222.62	16.13	34.6	25,852	25,852	0	15.64	72.70	290.80
62	642	105	0.52	127.63	111.99	40.83	67.11	5,578.90	16.13	31.0	19,920	19,920	0	15.64	56.02	224.07
57	601	105	0.46	127.63	111.99	40.83	67.11	4,935.18	16.13	27.4	16,496	16,496	0	15.64	46.39	185.56
52	684	105	0.40	127.63	111.99	40.83	67.11	4,291.46	16.13	23.9	16,326	16,326	0	15.64	45.91	183.64
47	569	105	0.34	127.63	111.99	40.83	67.11	3,647.74	16.13	20.3	11,544	11,544	0	15.64	32.46	129.85
42	667	105	0.28	127.63	111.99	40.83	67.11	3,004.02	16.13	16.7	11,144	11,144	0	15.64	31.34	125.35
37	621	105	0.22	127.63	111.99	40.83	67.11	2,360.30	16.13	13.1	8,152	8,152	0	15.64	22.92	91.70
32	504	105	0.16	127.63	111.99	40.83	67.11	1,716.58	16.13	9.5	4,812	4,812	0	15.64	13.53	54.12
27	229	105	0.10	127.63	111.99	40.83	67.11	1,072.87	16.13	6.0	1,366	1,366	0	15.64	3.84	15.37
22	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.00	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476										264,434		274,615	10,181		741.71	\$3,313

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 60 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

												PREV.				
Dry		Exist		NET REGRIG				POWER *		ENERGY	ENERGY	Add'l **	ELECT.	DOLLAR ***		
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	SAVINGS	
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	\$	
102	2	132	1.00	134.00	112.51	49.76	58.18	12,375.39	22.50	96.0	192	192	0	0	0.00	
97	104	127	0.94	132.82	112.49	48.05	59.89	11,300.72	21.32	83.1	8,640	8,640	0	0	0.00	
92	296	122	0.88	131.64	112.44	46.37	61.57	10,290.73	20.14	71.5	21,153	21,153	0	0	0.00	
87	407	117	0.82	130.46	112.35	44.71	63.23	9,337.34	18.96	61.0	24,844	24,844	0	0	0.00	
82	618	112	0.76	129.28	112.22	43.08	64.86	8,436.63	17.78	51.7	31,964	31,964	0	0	0.00	
77	776	107	0.70	128.10	112.06	41.47	66.47	7,582.37	16.60	43.4	33,678	33,678	0	0	0.00	
72	1009	102	0.64	126.92	111.85	39.55	68.39	6,737.83	15.42	35.8	36,147	38,532	60	2,325	79.05	
67	747	97	0.58	125.74	111.63	37.99	69.95	5,969.98	14.24	29.3	21,897	25,852	104	3,852	130.98	
62	642	92	0.52	124.56	111.40	36.43	71.51	5,235.63	13.06	23.6	15,136	19,920	128	4,656	158.30	
57	601	87	0.46	123.38	111.13	34.90	73.04	4,534.50	11.88	18.6	11,163	16,496	148	5,185	176.27	
52	684	82	0.40	122.20	110.86	33.38	74.56	3,862.66	10.70	14.3	9,748	16,326	195	6,383	217.01	
47	569	77	0.34	121.02	110.55	31.88	76.06	3,218.51	9.52	10.6	6,011	11,544	181	5,351	181.95	
42	667	72	0.28	119.84	110.24	30.39	77.55	2,599.61	8.34	7.5	4,986	11,144	230	5,928	201.54	
37	621	67	0.22	118.66	109.91	28.92	79.02	2,004.56	7.16	4.9	3,073	8,152	228	4,850	164.91	
32	504	62	0.16	117.48	109.56	27.46	80.48	1,431.41	5.98	3.0	1,488	4,812	195	3,129	106.38	
27	229	60	0.10	117.00	109.49	27.17	80.77	891.42	5.50	1.7	387	1,366	79	900	30.61	
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00	
8,476											230,507	274,615	1,549	42,559	\$1,447	

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 60 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *	ENERGY	PREV. ENERGY	Add'l **	ELECT.	WASTE HT.	TOTAL	DOLLAR **	
		Cond	LOAD	H1	H1a	H3	EFFECT			CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	AVAIL.	WASTE HT.	SAVINGS	
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB				KWH	KWH	KWH	KWH	KWH	BTU/LB	MMBTU	\$
102	2	126	1.00	132.58	112.48	47.72	60.22	11,956.16	21.08	86.9	174	192	0	18	20.10	0.48	2.54	
97	104	121	0.94	131.40	112.43	46.03	61.91	10,932.00	19.90	75.0	7,801	8,640	0	839	18.97	21.57	114.78	
92	296	116	0.88	130.22	112.32	44.39	63.55	9,970.10	18.72	64.4	19,049	21,153	0	2,104	17.90	52.83	282.84	
87	407	111	0.82	129.04	112.20	42.75	65.19	9,056.60	17.54	54.8	22,293	24,844	0	2,552	16.84	62.07	335.05	
82	618	106	0.76	127.86	112.03	41.15	66.79	8,192.84	16.36	46.2	28,561	31,964	0	3,403	15.83	80.15	436.29	
77	776	101	0.70	126.68	111.85	39.55	68.39	7,369.50	15.18	38.6	29,933	33,678	83	3,662	14.83	84.81	463.76	
72	1009	96	0.64	125.50	111.63	37.99	69.95	6,587.56	14.00	31.8	32,086	38,532	206	6,240	13.87	92.19	580.92	
67	747	91	0.58	124.32	111.40	36.43	71.51	5,839.74	12.82	25.8	19,283	25,852	206	6,363	12.92	56.36	441.78	
62	642	86	0.52	123.14	111.13	34.9	73.04	5,125.96	11.64	20.6	13,208	19,920	213	6,499	12.01	39.52	379.07	
57	601	81	0.46	121.96	110.86	33.38	74.56	4,442.06	10.46	16.0	9,629	16,496	225	6,642	11.10	29.63	344.37	
52	684	76	0.40	120.78	110.55	31.88	76.06	3,786.48	9.28	12.1	8,287	16,326	281	7,758	10.23	26.50	369.74	
47	569	71	0.34	119.60	110.24	30.39	77.55	3,156.67	8.10	8.8	5,016	11,544	250	6,277	9.36	16.81	280.67	
42	667	66	0.28	118.42	109.91	28.92	79.02	2,551.25	6.92	6.1	4,060	11,144	310	6,774	8.51	14.48	288.24	
37	621	61	0.22	117.24	109.56	27.46	80.48	1,968.19	5.74	3.9	2,419	8,152	301	5,432	7.68	9.39	222.22	
32	504	60	0.16	117.00	109.49	27.17	80.77	1,426.27	5.50	2.7	1,363	4,812	200	3,249	7.51	5.40	132.05	
27	229	60	0.10	117.00	109.49	27.17	80.77	891.42	5.50	1.7	387	1,366	72	907	7.51	1.53	36.98	
22	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
17	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
12	0	60	0.00	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00	
8,476											203,549		274,615	2,348	68,718		593.72	\$4,711

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 20 TONS
REFRIGERANT: R-22

LOAD PROFILE: LIGHT

DESUPERHEATER ONLY

Annual Dollar Savings: \$613/yr
Implementation Cost: \$2,828 (ht. exch. & pump installed)
Payback: 4.6 years

HY-SAVE ONLY

Annual Dollar Savings: \$59/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 25.4 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$702/yr
Implementation Cost: \$4,328 (combined cost)
Payback: 6.2 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 20 TONS LOAD PROFILE: LIGHT
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.000	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64
97	104	127	0.900	132.82	112.49	48.05	59.89	3,606.61	21.32	26.5	2,757
92	296	122	0.800	131.64	112.44	46.37	61.57	3,118.40	20.14	21.7	6,410
87	407	117	0.700	130.46	112.35	44.71	63.23	2,656.97	18.96	17.4	7,070
82	618	112	0.600	129.28	112.22	43.08	64.86	2,220.17	17.78	13.6	8,412
77	776	107	0.500	128.10	112.06	41.47	66.47	1,805.33	16.60	10.3	8,019
72	1009	105	0.400	127.63	111.99	40.83	67.11	1,430.49	16.13	8.0	8,028
67	747	105	0.300	127.63	111.99	40.83	67.11	1,072.87	16.13	6.0	4,457
62	642	105	0.200	127.63	111.99	40.83	67.11	715.24	16.13	4.0	2,554
57	601	105	0.100	127.63	111.99	40.83	67.11	357.62	16.13	2.0	1,195
52	684	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
47	569	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
42	667	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
37	621	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
32	504	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
27	229	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
22	0	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
17	0	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
12	0	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0
8,476											48,965

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: LIGHT
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	NET REGRIG		REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
						H3 BTU/LB	EFFECT BTU/LB					KWH				
102	2	126	1.000	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64	6	20.10	0.16	0.85
97	104	121	0.900	131.40	112.43	46.03	61.91	3,488.94	19.90	23.9	2,490	2,757	268	18.97	6.88	36.63
92	296	116	0.800	130.22	112.32	44.39	63.55	3,021.24	18.72	19.5	5,772	6,410	638	17.90	16.01	85.71
87	407	111	0.700	129.04	112.20	42.75	65.19	2,577.08	17.54	15.6	6,343	7,070	726	16.84	17.66	95.34
82	618	106	0.600	127.86	112.03	41.15	66.79	2,156.01	16.36	12.2	7,516	8,412	895	15.83	21.09	114.81
77	776	105	0.500	127.63	111.99	40.83	67.11	1,788.11	16.13	9.9	7,717	8,019	301	15.64	21.70	97.05
72	1009	105	0.400	127.63	111.99	40.83	67.11	1,430.49	16.13	8.0	8,028	8,028	0	15.64	22.57	90.30
67	747	105	0.300	127.63	111.99	40.83	67.11	1,072.87	16.13	6.0	4,457	4,457	0	15.64	12.53	50.14
62	642	105	0.200	127.63	111.99	40.83	67.11	715.24	16.13	4.0	2,554	2,554	0	15.64	7.18	28.73
57	601	105	0.100	127.63	111.99	40.83	67.11	357.62	16.13	2.0	1,195	1,195	0	15.64	3.36	13.45
52	684	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
47	569	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
42	667	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
37	621	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
32	504	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
27	229	105	0.000	127.63	111.99	40.83	67.11	0.00	16.13	0.0	0	0	0	15.64	0.00	0.00
22	0	105	0.000	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
17	0	105	0.000	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
12	0	105	0.000	127.63	111.99	40.83	67.11	0.00	0.00	0.0	0	0	0	0.00	0.00	0.00
8,476											46,131	48,965	2,834		129.16	\$613

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: LIGHT
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry		Exist		NET REGRIG				POWER *		ENERGY		PREV. ENERGY	Add'l **	ELECT.	DOLLAR ***
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	SAVINGS
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	\$
102	2	132	1.000	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64	64	0	0	0.00
97	104	127	0.900	132.82	112.49	48.05	59.89	3,606.61	21.32	26.5	2,757	2,757	0	0	0.00
92	296	122	0.800	131.64	112.44	46.37	61.57	3,118.40	20.14	21.7	6,410	6,410	0	0	0.00
87	407	117	0.700	130.46	112.35	44.71	63.23	2,656.97	18.96	17.4	7,070	7,070	0	0	0.00
82	618	112	0.600	129.28	112.22	43.08	64.86	2,220.17	17.78	13.6	8,412	8,412	0	0	0.00
77	776	107	0.500	128.10	112.06	41.47	66.47	1,805.33	16.60	10.3	8,019	8,019	0	0	0.00
72	1009	102	0.400	126.92	111.85	39.55	68.39	1,403.71	15.42	7.5	7,531	8,028	60	437	14.84
67	747	97	0.300	125.74	111.63	37.99	69.95	1,029.31	14.24	5.1	3,775	4,457	104	579	19.67
62	642	92	0.200	124.56	111.40	36.43	71.51	671.23	13.06	3.0	1,941	2,554	128	486	16.51
57	601	87	0.100	123.38	111.13	34.90	73.04	328.59	11.88	1.3	809	1,195	148	238	8.10
52	684	82	0.000	122.20	110.86	33.38	74.56	0.00	10.70	0.0	0	0	0	0	0.00
47	569	77	0.000	121.02	110.55	31.88	76.06	0.00	9.52	0.0	0	0	0	0	0.00
42	667	72	0.000	119.84	110.24	30.39	77.55	0.00	8.34	0.0	0	0	0	0	0.00
37	621	67	0.000	118.66	109.91	28.92	79.02	0.00	7.16	0.0	0	0	0	0	0.00
32	504	62	0.000	117.48	109.56	27.46	80.48	0.00	5.98	0.0	0	0	0	0	0.00
27	229	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
22	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
17	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
12	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	0.00
8,476											46,786	48,965	440	1,739	\$59

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: LIGHT
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG EFFECT BTU/LB	REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT KWH	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
102	2	126	1.000	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64	0	6	20.10	0.16	0.85
97	104	121	0.900	131.40	112.43	46.03	61.91	3,488.94	19.90	23.9	2,490	2,757	0	268	18.97	6.88	36.63
92	296	116	0.800	130.22	112.32	44.39	63.55	3,021.24	18.72	19.5	5,772	6,410	0	638	17.90	16.01	85.71
87	407	111	0.700	129.04	112.20	42.75	65.19	2,577.08	17.54	15.6	6,343	7,070	0	726	16.84	17.66	95.34
82	618	106	0.600	127.86	112.03	41.15	66.79	2,156.01	16.36	12.2	7,516	8,412	0	895	15.83	21.09	114.81
77	776	101	0.500	126.68	111.85	39.55	68.39	1,754.64	15.18	9.2	7,127	8,019	83	809	14.83	20.19	108.26
72	1009	96	0.400	125.50	111.63	37.99	69.95	1,372.41	14.00	6.6	6,685	8,028	206	1,137	13.87	19.21	115.47
67	747	91	0.300	124.32	111.40	36.43	71.51	1,006.85	12.82	4.5	3,325	4,457	206	926	12.92	9.72	70.36
62	642	86	0.200	123.14	111.13	34.9	73.04	657.17	11.64	2.6	1,693	2,554	0	861	12.01	5.07	49.53
57	601	81	0.100	121.96	110.86	33.38	74.56	321.89	10.46	1.2	698	1,195	0	498	11.10	2.15	25.51
52	684	76	0.000	120.78	110.55	31.88	76.06	0.00	9.28	0.0	0	0	0	0	10.23	0.00	0.00
47	569	71	0.000	119.60	110.24	30.39	77.55	0.00	8.10	0.0	0	0	0	0	9.36	0.00	0.00
42	667	66	0.000	118.42	109.91	28.92	79.02	0.00	6.92	0.0	0	0	0	0	8.51	0.00	0.00
37	621	61	0.000	117.24	109.56	27.46	80.48	0.00	5.74	0.0	0	0	0	0	7.68	0.00	0.00
32	504	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
27	229	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
22	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
17	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
12	0	60	0.000	117.00	109.49	27.17	80.77	0.00	5.50	0.0	0	0	0	0	7.51	0.00	0.00
8,476											41,707	48,965	496	6,762		118.14	\$702

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 20 TONS
REFRIGERANT: R-22

LOAD PROFILE: HEAVY

DESUPERHEATER ONLY

Annual Dollar Savings: \$1,751/yr
Implementation Cost: \$2,828 (ht. exch. & pump installed)
Payback: 1.6 years

HY-SAVE ONLY

Annual Dollar Savings: \$1,169/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 1.3 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$2,781/yr
Implementation Cost: \$4,328 (combined cost)
Payback: 1.6 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 20 TONS LOAD PROFILE: HEAVY
REFRIGERANT: R-22

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	132	1.00	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64
97	104	127	0.98	132.82	112.49	48.05	59.89	3,927.20	21.32	28.9	3,002
92	296	122	0.96	131.64	112.44	46.37	61.57	3,742.08	20.14	26.0	7,692
87	407	117	0.94	130.46	112.35	44.71	63.23	3,567.93	18.96	23.3	9,493
82	618	112	0.92	129.28	112.22	43.08	64.86	3,404.26	17.78	20.9	12,898
77	776	107	0.90	128.10	112.06	41.47	66.47	3,249.59	16.60	18.6	14,433
72	1009	105	0.88	127.63	111.99	40.83	67.11	3,147.07	16.13	17.5	17,661
67	747	105	0.86	127.63	111.99	40.83	67.11	3,075.55	16.13	17.1	12,778
62	642	105	0.84	127.63	111.99	40.83	67.11	3,004.02	16.13	16.7	10,726
57	601	105	0.82	127.63	111.99	40.83	67.11	2,932.50	16.13	16.3	9,802
52	684	105	0.80	127.63	111.99	40.83	67.11	2,860.97	16.13	15.9	10,884
47	569	105	0.78	127.63	111.99	40.83	67.11	2,789.45	16.13	15.5	8,827
42	667	105	0.76	127.63	111.99	40.83	67.11	2,717.93	16.13	15.1	10,083
37	621	105	0.74	127.63	111.99	40.83	67.11	2,646.40	16.13	14.7	9,140
32	504	105	0.72	127.63	111.99	40.83	67.11	2,574.88	16.13	14.3	7,218
27	229	105	0.70	127.63	111.99	40.83	67.11	2,503.35	16.13	13.9	3,188
22	0	105	0.68	127.63	111.99	40.83	67.11	2,431.83	16.13	13.5	0
17	0	105	0.66	127.63	111.99	40.83	67.11	2,360.30	16.13	13.1	0
12	0	105	0.64	127.63	111.99	40.83	67.11	2,288.78	16.13	12.7	0
8,476											147,889

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: HEAVY
 REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

												PREV.					
Dry		Exist		NET REGRIG				POWER *		ENERGY		ENERGY	ELECT.	WASTE HT.	TOTAL	DOLLAR **	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	SAVINGS	AVAIL.	WASTE HT.	SAVINGS	
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	BTU/LB	MMBTU	\$
102	2	126	1.00	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64	6	20.10	0.16	0.85	
97	104	121	0.98	131.40	112.43	46.03	61.91	3,799.06	19.90	26.1	2,711	3,002	291	18.97	7.50	39.89	
92	296	116	0.96	130.22	112.32	44.39	63.55	3,625.49	18.72	23.4	6,927	7,692	765	17.90	19.21	102.85	
87	407	111	0.94	129.04	112.20	42.75	65.19	3,460.65	17.54	20.9	8,518	9,493	975	16.84	23.72	128.03	
82	618	106	0.92	127.86	112.03	41.15	66.79	3,305.88	16.36	18.6	11,525	12,898	1,373	15.83	32.34	176.05	
77	776	105	0.90	127.63	111.99	40.83	67.11	3,218.60	16.13	17.9	13,891	14,433	542	15.64	39.06	174.69	
72	1009	105	0.88	127.63	111.99	40.83	67.11	3,147.07	16.13	17.5	17,661	17,661	0	15.64	49.66	198.65	
67	747	105	0.86	127.63	111.99	40.83	67.11	3,075.55	16.13	17.1	12,778	12,778	0	15.64	35.93	143.73	
62	642	105	0.84	127.63	111.99	40.83	67.11	3,004.02	16.13	16.7	10,726	10,726	0	15.64	30.16	120.65	
57	601	105	0.82	127.63	111.99	40.83	67.11	2,932.50	16.13	16.3	9,802	9,802	0	15.64	27.56	110.26	
52	684	105	0.80	127.63	111.99	40.83	67.11	2,860.97	16.13	15.9	10,884	10,884	0	15.64	30.61	122.42	
47	569	105	0.78	127.63	111.99	40.83	67.11	2,789.45	16.13	15.5	8,827	8,827	0	15.64	24.82	99.30	
42	667	105	0.76	127.63	111.99	40.83	67.11	2,717.93	16.13	15.1	10,083	10,083	0	15.64	28.35	113.41	
37	621	105	0.74	127.63	111.99	40.83	67.11	2,646.40	16.13	14.7	9,140	9,140	0	15.64	25.70	102.81	
32	504	105	0.72	127.63	111.99	40.83	67.11	2,574.88	16.13	14.3	7,218	7,218	0	15.64	20.30	81.19	
27	229	105	0.70	127.63	111.99	40.83	67.11	2,503.35	16.13	13.9	3,188	3,188	0	15.64	8.97	35.86	
22	0	105	0.68	127.63	111.99	40.83	67.11	2,431.83	0.00	0.0	0	0	0	0.00	0.00	0.00	
17	0	105	0.66	127.63	111.99	40.83	67.11	2,360.30	0.00	0.0	0	0	0	0.00	0.00	0.00	
12	0	105	0.64	127.63	111.99	40.83	67.11	2,288.78	0.00	0.0	0	0	0	0.00	0.00	0.00	
8,476											143,936	147,889	3,953		404.06	\$1,751	

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: HEAVY
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

												PREV.				
Dry	Exist		NET REGRIG					POWER *	ENERGY	ENERGY	Add'l **	ELECT.	DOLLAR ***			
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT	CONSMPT	Fan	SAVINGS	SAVINGS	
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH	KWH	KWH	KWH	\$	
102	2	132	1.00	134.00	112.51	49.76	58.18	4,125.13	22.50	32.0	64	64	0	0	0.00	
97	104	127	0.98	132.82	112.49	48.05	59.89	3,927.20	21.32	28.9	3,002	3,002	0	0	0.00	
92	296	122	0.96	131.64	112.44	46.37	61.57	3,742.08	20.14	26.0	7,692	7,692	0	0	0.00	
87	407	117	0.94	130.46	112.35	44.71	63.23	3,567.93	18.96	23.3	9,493	9,493	0	0	0.00	
82	618	112	0.92	129.28	112.22	43.08	64.86	3,404.26	17.78	20.9	12,898	12,898	0	0	0.00	
77	776	107	0.90	128.10	112.06	41.47	66.47	3,249.59	16.60	18.6	14,433	14,433	0	0	0.00	
72	1009	102	0.88	126.92	111.85	39.55	68.39	3,088.17	15.42	16.4	16,567	17,661	60	1,033	35.12	
67	747	97	0.86	125.74	111.63	37.99	69.95	2,950.68	14.24	14.5	10,822	12,778	104	1,852	62.96	
62	642	92	0.84	124.56	111.40	36.43	71.51	2,819.19	13.06	12.7	8,150	10,726	128	2,448	83.24	
57	601	87	0.82	123.38	111.13	34.90	73.04	2,694.41	11.88	11.0	6,633	9,802	148	3,020	102.70	
52	684	82	0.80	122.20	110.86	33.38	74.56	2,575.11	10.70	9.5	6,498	10,884	195	4,190	142.46	
47	569	77	0.78	121.02	110.55	31.88	76.06	2,461.21	9.52	8.1	4,597	8,827	181	4,050	137.69	
42	667	72	0.76	119.84	110.24	30.39	77.55	2,352.03	8.34	6.8	4,511	10,083	230	5,341	181.60	
37	621	67	0.74	118.66	109.91	28.92	79.02	2,247.53	7.16	5.5	3,446	9,140	228	5,466	185.84	
32	504	62	0.72	117.48	109.56	27.46	80.48	2,147.12	5.98	4.4	2,231	7,218	195	4,791	162.89	
27	229	60	0.70	117.00	109.49	27.17	80.77	2,079.98	5.50	3.9	903	3,188	79	2,206	75.00	
22	0	60	0.68	117.00	109.49	27.17	80.77	2,020.55	5.50	3.8	0	0	0	0	0.00	
17	0	60	0.66	117.00	109.49	27.17	80.77	1,961.12	5.50	3.7	0	0	0	0	0.00	
12	0	60	0.64	117.00	109.49	27.17	80.77	1,901.70	5.50	3.6	0	0	0	0	0.00	
8,476											111,943	147,889	1,549	34,397	\$1,169	

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: HEAVY
REFRIGERANT: R-22 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	NET REGRIG		REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT KWH		Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
						H3 BTU/LB	EFFECT BTU/LB											
102	2	126	1.00	132.58	112.48	47.72	60.22	3,985.39	21.08	29.0	58	64	64	0	6	20.10	0.16	0.85
97	104	121	0.98	131.40	112.43	46.03	61.91	3,799.06	19.90	26.1	2,711	3,002	3,002	0	291	18.97	7.50	39.89
92	296	116	0.96	130.22	112.32	44.39	63.55	3,625.49	18.72	23.4	6,927	7,692	7,692	0	765	17.90	19.21	102.85
87	407	111	0.94	129.04	112.20	42.75	65.19	3,460.65	17.54	20.9	8,518	9,493	9,493	0	975	16.84	23.72	128.03
82	618	106	0.92	127.86	112.03	41.15	66.79	3,305.88	16.36	18.6	11,525	12,898	12,898	0	1,373	15.83	32.34	176.05
77	776	101	0.90	126.68	111.85	39.55	68.39	3,158.36	15.18	16.5	12,828	14,433	14,433	83	1,522	14.83	36.35	197.14
72	1009	96	0.88	125.50	111.63	37.99	69.95	3,019.30	14.00	14.6	14,706	17,661	17,661	206	2,748	13.87	42.25	262.45
67	747	91	0.86	124.32	111.40	36.43	71.51	2,886.31	12.82	12.8	9,531	12,778	12,778	206	3,041	12.92	27.86	214.80
62	642	86	0.84	123.14	111.13	34.9	73.04	2,760.13	11.64	11.1	7,112	10,726	10,726	213	3,401	12.01	21.28	200.78
57	601	81	0.82	121.96	110.86	33.38	74.56	2,639.48	10.46	9.5	5,721	9,802	9,802	225	3,855	11.10	17.61	201.52
52	684	76	0.80	120.78	110.55	31.88	76.06	2,524.32	9.28	8.1	5,525	10,884	10,884	281	5,078	10.23	17.66	243.31
47	569	71	0.78	119.60	110.24	30.39	77.55	2,413.93	8.10	6.7	3,836	8,827	8,827	250	4,741	9.36	12.86	212.63
42	667	66	0.76	118.42	109.91	28.92	79.02	2,308.28	6.92	5.5	3,674	10,083	10,083	310	6,099	8.51	13.10	259.78
37	621	61	0.74	117.24	109.56	27.46	80.48	2,206.76	5.74	4.4	2,712	9,140	9,140	301	6,127	7.68	10.52	250.40
32	504	60	0.72	117.00	109.49	27.17	80.77	2,139.41	5.50	4.1	2,045	7,218	7,218	200	4,973	7.51	8.10	201.47
27	229	60	0.70	117.00	109.49	27.17	80.77	2,079.98	5.50	3.9	903	3,188	3,188	72	2,213	7.51	3.58	89.55
22	0	60	0.68	117.00	109.49	27.17	80.77	2,020.55	5.50	3.8	0	0	0	0	0	7.51	0.00	0.00
17	0	60	0.66	117.00	109.49	27.17	80.77	1,961.12	5.50	3.7	0	0	0	0	0	7.51	0.00	0.00
12	0	60	0.64	117.00	109.49	27.17	80.77	1,901.70	5.50	3.6	0	0	0	0	0	7.51	0.00	0.00
8,476											98,332	147,889	147,889	2,348	47,209		294.09	\$2,781

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 20 TONS
REFRIGERANT: R-12

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$849/yr
Implementation Cost: \$2,828 (ht. exch. & pump installed)
Payback: 3.3 years

HY-SAVE ONLY

Annual Dollar Savings: \$787/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 1.9 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$1,507/yr
Implementation Cost: \$4,328 (combined cost)
Payback: 2.9 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 20 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-12

BIN CALCULATION

Dry	Exist			NET REGRIG					POWER *		ENERGY
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
<hr/>											
102	2	117	1.00	100.50	89.16	35.69	44.16	5,434.78	18.00	33.7	67
97	104	112	0.94	99.57	88.77	34.44	45.41	4,968.07	17.07	29.2	3,041
92	296	107	0.88	98.64	88.36	33.20	46.65	4,527.33	16.14	25.2	7,460
87	407	102	0.82	97.72	87.93	31.96	47.89	4,109.42	15.22	21.6	8,775
82	618	100	0.76	97.34	87.77	31.47	48.38	3,770.15	14.84	19.3	11,922
77	776	100	0.70	97.34	87.77	31.47	48.38	3,472.51	14.84	17.8	13,788
72	1009	100	0.64	97.34	87.77	31.47	48.38	3,174.87	14.84	16.2	16,392
67	747	100	0.58	97.34	87.77	31.47	48.38	2,877.22	14.84	14.7	10,998
62	642	100	0.52	97.34	87.77	31.47	48.38	2,579.58	14.84	13.2	8,474
57	601	100	0.46	97.34	87.77	31.47	48.38	2,281.93	14.84	11.7	7,018
52	684	100	0.40	97.34	87.77	31.47	48.38	1,984.29	14.84	10.2	6,945
47	569	100	0.34	97.34	87.77	31.47	48.38	1,686.65	14.84	8.6	4,911
42	667	100	0.28	97.34	87.77	31.47	48.38	1,389.00	14.84	7.1	4,741
37	621	100	0.22	97.34	87.77	31.47	48.38	1,091.36	14.84	5.6	3,468
32	504	100	0.16	97.34	87.77	31.47	48.38	793.72	14.84	4.1	2,047
27	229	100	0.10	97.34	87.77	31.47	48.38	496.07	14.84	2.5	581
22	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0
17	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0
12	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0
<hr/>											
8,476											110,627

* Motor effeciency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-12 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *	ENERGY	PREV.	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** \$
		Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB			CONSMPT KW	CONSMPT KWH	ENERGY CONSMPT KWH				
102	2	114	1.00	99.94	88.93	34.94	44.91	5,344.02	17.44	32.1	64	67	3	11.01	0.12	0.58
97	104	109	0.94	99.02	88.52	33.69	46.16	4,887.35	16.52	27.8	2,895	3,041	146	10.50	5.34	26.32
92	296	104	0.88	98.09	88.10	32.45	47.40	4,455.70	15.59	24.0	7,090	7,460	370	9.99	13.18	65.28
87	407	100	0.82	97.34	87.77	31.47	48.38	4,067.80	14.84	20.8	8,471	8,775	304	9.57	15.84	73.70
82	618	100	0.76	97.34	87.77	31.47	48.38	3,770.15	14.84	19.3	11,922	11,922	0	9.57	22.30	89.19
77	776	100	0.70	97.34	87.77	31.47	48.38	3,472.51	14.84	17.8	13,788	13,788	0	9.57	25.79	103.15
72	1009	100	0.64	97.34	87.77	31.47	48.38	3,174.87	14.84	16.2	16,392	16,392	0	9.57	30.66	122.63
67	747	100	0.58	97.34	87.77	31.47	48.38	2,877.22	14.84	14.7	10,998	10,998	0	9.57	20.57	82.27
62	642	100	0.52	97.34	87.77	31.47	48.38	2,579.58	14.84	13.2	8,474	8,474	0	9.57	15.85	63.40
57	601	100	0.46	97.34	87.77	31.47	48.38	2,281.93	14.84	11.7	7,018	7,018	0	9.57	13.12	52.50
52	684	100	0.40	97.34	87.77	31.47	48.38	1,984.29	14.84	10.2	6,945	6,945	0	9.57	12.99	51.96
47	569	100	0.34	97.34	87.77	31.47	48.38	1,686.65	14.84	8.6	4,911	4,911	0	9.57	9.18	36.74
42	667	100	0.28	97.34	87.77	31.47	48.38	1,389.00	14.84	7.1	4,741	4,741	0	9.57	8.87	35.47
37	621	100	0.22	97.34	87.77	31.47	48.38	1,091.36	14.84	5.6	3,468	3,468	0	9.57	6.49	25.94
32	504	100	0.16	97.34	87.77	31.47	48.38	793.72	14.84	4.1	2,047	2,047	0	9.57	3.83	15.31
27	229	100	0.10	97.34	87.77	31.47	48.38	496.07	14.84	2.5	581	581	0	9.57	1.09	4.35
22	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0	0	0	0.00	0.00	0.00
17	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0	0	0	0.00	0.00	0.00
12	0	100	0.00	97.34	87.77	31.47	48.38	0.00	14.84	0.0	0	0	0	0.00	0.00	0.00
8,476											109,804	110,627	823		205.20	\$849

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
REFRIGERANT: R-12 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours	Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT KWH	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR *** SAVINGS \$	
		Cond	LOAD	H1	H1a	H3	EFFECT											
		Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB											
102	2	114	1.00	99.94	88.93	34.94	44.91	5,344.02	17.44	32.1	64	67	0	3	11.01	0.12	0.58	
97	104	109	0.94	99.02	88.52	33.69	46.16	4,887.35	16.52	27.8	2,895	3,041	0	146	10.50	5.34	26.32	
92	296	104	0.88	98.09	88.10	32.45	47.40	4,455.70	15.59	24.0	7,090	7,460	0	370	9.99	13.18	65.28	
87	407	99	0.82	97.16	87.68	31.22	48.63	4,046.88	14.66	20.5	8,326	8,775	47	402	9.48	15.61	76.14	
82	618	94	0.76	96.23	87.23	30.01	49.84	3,659.71	13.73	17.3	10,707	11,922	309	906	9.00	20.36	112.22	
77	776	89	0.70	95.30	86.79	28.79	51.06	3,290.25	12.80	14.5	11,269	13,788	557	1,963	8.51	21.73	153.65	
72	1009	84	0.64	94.38	86.33	27.59	52.26	2,939.15	11.88	12.0	12,148	16,392	865	3,379	8.05	23.87	210.37	
67	747	79	0.58	93.45	85.86	26.40	53.45	2,604.30	10.95	9.8	7,345	10,998	713	2,939	7.59	14.77	159.01	
62	642	74	0.52	92.52	85.38	25.21	54.64	2,284.04	10.02	7.9	5,066	8,474	659	2,749	7.14	10.47	135.34	
57	601	69	0.46	91.59	84.90	24.03	55.82	1,977.79	9.09	6.2	3,726	7,018	650	2,642	6.69	7.95	121.64	
52	684	64	0.40	90.66	84.41	22.87	56.98	1,684.80	8.16	4.7	3,242	6,945	770	2,933	6.25	7.20	128.53	
47	569	60	0.34	89.91	84.01	21.93	57.92	1,408.84	7.41	3.6	2,048	4,911	595	2,268	5.90	4.73	96.03	
42	667	60	0.28	89.91	84.01	21.93	57.92	1,160.22	7.41	3.0	1,977	4,741	460	2,303	5.90	4.57	96.58	
37	621	60	0.22	89.91	84.01	21.93	57.92	911.60	7.41	2.3	1,446	3,468	309	1,713	5.90	3.34	71.60	
32	504	60	0.16	89.91	84.01	21.93	57.92	662.98	7.41	1.7	854	2,047	191	1,003	5.90	1.97	41.97	
27	229	60	0.10	89.91	84.01	21.93	57.92	414.36	7.41	1.1	242	581	68	270	5.90	0.56	11.43	
22	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	5.90	0.00	0.00	
17	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	5.90	0.00	0.00	
12	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	5.90	0.00	0.00	
8,476											78,446		110,627	6,191	25,990	155.76		\$1,507

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-12 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG EFFECT BTU/LB	REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	Add'l ** Fan KWH	ELECT. SAVINGS KWH	DOLLAR *** SAVINGS \$
												KWH			
102	2	117	1.00	100.50	89.16	35.69	44.16	5,434.78	18.00	33.7	67	67	0	0	0.00
97	104	112	0.94	99.57	88.77	34.44	45.41	4,968.07	17.07	29.2	3,041	3,041	0	0	0.00
92	296	107	0.88	98.64	88.36	33.20	46.65	4,527.33	16.14	25.2	7,460	7,460	0	0	0.00
87	407	102	0.82	97.72	87.93	31.96	47.89	4,109.42	15.22	21.6	8,775	8,775	0	0	0.00
82	618	97	0.76	96.70	87.46	30.76	49.09	3,715.62	14.20	18.2	11,243	11,922	136	544	18.48
77	776	92	0.70	95.77	87.00	29.56	50.29	3,340.62	13.27	15.3	11,861	13,788	355	1,572	53.44
72	1009	87	0.64	94.84	86.54	28.36	51.49	2,983.10	12.34	12.7	12,807	16,392	617	2,968	100.91
67	747	82	0.58	93.91	86.08	27.16	52.69	2,641.87	11.41	10.4	7,764	10,998	536	2,697	91.70
62	642	77	0.52	92.98	85.62	25.96	53.89	2,315.83	10.48	8.4	5,372	8,474	512	2,590	88.06
57	601	72	0.46	92.05	85.16	24.76	55.09	2,003.99	9.55	6.6	3,966	7,018	515	2,536	86.24
52	684	67	0.40	91.12	84.70	23.56	56.29	1,705.45	8.62	5.1	3,467	6,945	619	2,859	97.20
47	569	62	0.34	90.29	84.24	22.36	57.49	1,419.38	7.79	3.8	2,169	4,911	537	2,204	74.95
42	667	60	0.28	89.91	84.01	21.93	57.92	1,160.22	7.41	3.0	1,977	4,741	505	2,259	76.80
37	621	60	0.22	89.91	84.01	21.93	57.92	911.60	7.41	2.3	1,446	3,468	339	1,683	57.22
32	504	60	0.16	89.91	84.01	21.93	57.92	662.98	7.41	1.7	854	2,047	209	984	33.46
27	229	60	0.10	89.91	84.01	21.93	57.92	414.36	7.41	1.1	242	581	75	264	8.97
22	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	0.00
17	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	0.00
12	0	60	0.00	89.91	84.01	21.93	57.92	0.00	7.41	0.0	0	0	0	0	0.00
8,476											82,514	110,627	4,954	23,159	\$787

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

ECONOMIC SUMMARY

TONNAGE: 20 TONS
REFRIGERANT: R-502

LOAD PROFILE: MEDIUM

DESUPERHEATER ONLY

Annual Dollar Savings: \$3,825/yr
Implementation Cost: \$2,828 (ht. exch. & pump installed)
Payback: 0.7 years

HY-SAVE ONLY

Annual Dollar Savings: \$2,093/yr
Implementation Cost: \$1,500 (1/5 hp pump installed)
Payback: 0.7 years

HY-SAVE AND DESUPERHEATING

Total Dollar Savings: \$4,612/yr
Implementation Cost: \$4,328 (combined cost)
Payback: 0.9 years

EXAMPLE: NORMAL UNIT, NO HY-SAVE OR DESUPERHEATING

TONNAGE: 20 TONS LOAD PROFILE: MEDIUM
REFRIGERANT: R-502

BIN CALCULATION

Dry	Exist	NET REGRIG							POWER *	ENERGY	
Bulb	Hours	Cond	LOAD	H1	H1a	H3	EFFECT	REFRIG. FLOW	WORK	CONSMPT	CONSMPT
Temp.	(H)	Temp	FACTOR	BTU/LB	BTU/LB	BTU/LB	BTU/LB	LBS/HR	BTU/LB	KW	KWH
102	2	117	1.00	115.00	87.60	42.83	31.51	7,616.63	36.00	94.5	189
97	104	112	0.94	113.78	87.39	41.27	33.07	6,821.89	34.78	81.8	8,508
92	296	107	0.88	112.55	87.14	39.72	34.62	6,100.52	33.55	70.6	20,889
87	407	102	0.82	111.33	86.87	38.19	36.15	5,443.98	32.33	60.7	24,700
82	618	100	0.76	110.84	86.76	37.58	36.76	4,961.92	31.84	54.5	33,665
77	776	100	0.70	110.84	86.76	37.58	36.76	4,570.18	31.84	50.2	38,935
72	1009	100	0.64	110.84	86.76	37.58	36.76	4,178.45	31.84	45.9	46,286
67	747	100	0.58	110.84	86.76	37.58	36.76	3,786.72	31.84	41.6	31,055
62	642	100	0.52	110.84	86.76	37.58	36.76	3,394.99	31.84	37.3	23,929
57	601	100	0.46	110.84	86.76	37.58	36.76	3,003.26	31.84	33.0	19,816
52	684	100	0.40	110.84	86.76	37.58	36.76	2,611.53	31.84	28.7	19,611
47	569	100	0.34	110.84	86.76	37.58	36.76	2,219.80	31.84	24.4	13,867
42	667	100	0.28	110.84	86.76	37.58	36.76	1,828.07	31.84	20.1	13,386
37	621	100	0.22	110.84	86.76	37.58	36.76	1,436.34	31.84	15.8	9,793
32	504	100	0.16	110.84	86.76	37.58	36.76	1,044.61	31.84	11.5	5,780
27	229	100	0.10	110.84	86.76	37.58	36.76	652.88	31.84	7.2	1,641
22	0	100	0.00	110.84	86.76	37.58	36.76	0.00	31.84	0.0	0
17	0	100	0.00	110.84	86.76	37.58	36.76	0.00	31.84	0.0	0
12	0	100	0.00	110.84	86.76	37.58	36.76	0.00	31.84	0.0	0
8,476											312,050

* Motor efficiency of 85% assumed

EXAMPLE: DESUPERHEATING WITHOUT HY-SAVE

TONNAGE: 20 TONS

GAS COST: \$3.20/MCF

LOAD PROFILE: MEDIUM

REFRIGERANT: R-502

ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	NET REGRIG		REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
						H3 BTU/LB	EFFECT BTU/LB					KWH				
102	2	112	1.00	113.78	88.93	34.94	39.40	6,091.37	34.78	73.0	146	189	43	24.85	0.30	2.67
97	104	107	0.94	112.55	88.52	33.69	40.65	5,549.82	33.55	64.2	6,677	8,508	1,831	24.03	13.87	117.74
92	296	102	0.88	111.33	88.10	32.45	41.89	5,041.78	32.33	56.2	16,636	20,889	4,253	23.23	34.67	283.28
87	407	100	0.82	110.84	87.77	31.47	42.87	4,590.62	31.84	50.4	20,512	24,700	4,187	23.07	43.10	314.79
82	618	100	0.76	110.84	87.77	31.47	42.87	4,254.72	31.84	46.7	28,867	33,665	4,798	23.07	60.66	405.78
77	776	100	0.70	110.84	87.77	31.47	42.87	3,918.82	31.84	43.0	33,386	38,935	5,549	23.07	70.16	469.30
72	1009	100	0.64	110.84	87.77	31.47	42.87	3,582.93	31.84	39.3	39,689	46,286	6,597	23.07	83.40	557.90
67	747	100	0.58	110.84	87.77	31.47	42.87	3,247.03	31.84	35.6	26,629	31,055	4,426	23.07	55.96	374.31
62	642	100	0.52	110.84	87.77	31.47	42.87	2,911.13	31.84	32.0	20,518	23,929	3,410	23.07	43.12	288.42
57	601	100	0.46	110.84	87.77	31.47	42.87	2,575.23	31.84	28.3	16,992	19,816	2,824	23.07	35.71	238.85
52	684	100	0.40	110.84	87.77	31.47	42.87	2,239.33	31.84	24.6	16,816	19,611	2,795	23.07	35.34	236.38
47	569	100	0.34	110.84	87.77	31.47	42.87	1,903.43	31.84	20.9	11,890	13,867	1,976	23.07	24.99	167.14
42	667	100	0.28	110.84	87.77	31.47	42.87	1,567.53	31.84	17.2	11,479	13,386	1,908	23.07	24.12	161.35
37	621	100	0.22	110.84	87.77	31.47	42.87	1,231.63	31.84	13.5	8,397	9,793	1,396	23.07	17.64	118.03
32	504	100	0.16	110.84	87.77	31.47	42.87	895.73	31.84	9.8	4,956	5,780	824	23.07	10.41	69.67
27	229	100	0.10	110.84	87.77	31.47	42.87	559.83	31.84	6.1	1,407	1,641	234	23.07	2.96	19.78
22	0	100	0.00	110.84	87.77	31.47	42.87	0.00	31.84	0.0	0	0	0	0.00	0.00	0.00
17	0	100	0.00	110.84	87.77	31.47	42.87	0.00	31.84	0.0	0	0	0	0.00	0.00	0.00
12	0	100	0.00	110.84	87.77	31.47	42.87	0.00	31.84	0.0	0	0	0	0.00	0.00	0.00
8,476											264,998	312,050	47,052		556.40	\$3,825

* Motor efficiency of 85% assumed

** Assumes a Boiler Efficiency of 80%

EXAMPLE: HY-SAVE ONLY

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-502 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry		Exist		NET REGRIG				REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER *		ENERGY		PREV. ENERGY		Add'l ** Fan		ELECT. SAVINGS		DOLLAR *** SAVINGS	
Bulb Temp.	Hours (H)	Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	EFFECT BTU/LB			CONSMPT KW	CONSMPT KWH	CONSMPT KWH	CONSMPT KWH	CONSMPT KWH	CONSMPT KWH	KWH	KWH	KWH	KWH	\$	\$
102	2	117	1.00	115.00	87.60	42.83	31.51	7,616.63	36.00	94.5	189	189	189	0	0	0	0	0	0	0.00	
97	104	112	0.94	113.78	87.39	41.27	33.07	6,821.89	34.78	81.8	8,508	8,508	8,508	0	0	0	0	0	0	0.00	
92	296	107	0.88	112.55	87.14	39.72	34.62	6,100.52	33.55	70.6	20,889	20,889	20,889	0	0	0	0	0	0	0.00	
87	407	102	0.82	111.33	86.87	38.19	36.15	5,443.98	32.33	60.7	24,700	24,700	24,700	0	0	0	0	0	0	0.00	
82	618	97	0.76	110.11	86.57	36.67	37.67	4,842.05	31.11	51.9	32,099	33,665	33,665	136	1,431	136	1,431	48.65	48.65		
77	776	92	0.70	108.88	86.25	35.17	39.17	4,289.00	29.88	44.2	34,290	38,935	38,935	355	4,290	355	4,290	145.84	145.84		
72	1009	87	0.64	107.66	85.91	33.67	40.67	3,776.74	28.66	37.3	37,658	46,286	46,286	617	8,012	617	8,012	272.39	272.39		
67	747	82	0.58	106.43	85.55	32.19	42.15	3,302.49	27.43	31.2	23,332	31,055	31,055	536	7,186	536	7,186	244.32	244.32		
62	642	77	0.52	105.21	85.16	30.72	43.62	2,861.07	26.21	25.9	16,600	23,929	23,929	512	6,817	512	6,817	231.79	231.79		
57	601	72	0.46	103.98	84.77	29.27	45.07	2,449.52	24.98	21.1	12,680	19,816	19,816	515	6,621	515	6,621	225.10	225.10		
52	684	67	0.40	102.76	84.35	27.82	46.52	2,063.63	23.76	16.9	11,564	19,611	19,611	619	7,428	619	7,428	252.55	252.55		
47	569	62	0.34	101.53	83.93	26.39	47.95	1,701.77	22.53	13.2	7,522	13,867	13,867	537	5,807	537	5,807	197.45	197.45		
42	667	60	0.28	100.31	83.76	25.81	48.53	1,384.71	21.31	10.2	6,786	13,386	13,386	505	6,095	505	6,095	207.24	207.24		
37	621	60	0.22	100.31	83.76	25.81	48.53	1,087.99	21.31	8.0	4,964	9,793	9,793	339	4,490	339	4,490	152.65	152.65		
32	504	60	0.16	100.31	83.76	25.81	48.53	791.26	21.31	5.8	2,930	5,780	5,780	209	2,641	209	2,641	89.78	89.78		
27	229	60	0.10	100.31	83.76	25.81	48.53	494.54	21.31	3.6	832	1,641	1,641	75	734	75	734	24.96	24.96		
22	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	0	0	0	0	0	0.00	
17	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	0	0	0	0	0	0.00	
12	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	0	0	0	0	0	0.00	
8,476											245,545	312,050	312,050	4,954	61,551	4,954	61,551	\$2,093			

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%

EXAMPLE: DESUPERHEATING AND HY-SAVE

TONNAGE: 20 TONS GAS COST: \$3.20/MCF LOAD PROFILE: MEDIUM
 REFRIGERANT: R-502 ELECT. COST: \$0.034/KWH

BIN CALCULATION

Dry Bulb Temp.	Hours (H)	Exist Cond Temp	LOAD FACTOR	H1 BTU/LB	H1a BTU/LB	H3 BTU/LB	NET REGRIG EFFECT BTU/LB	REFRIG. FLOW LBS/HR	WORK BTU/LB	POWER * CONSMPT KW	ENERGY CONSMPT KWH	PREV. ENERGY CONSMPT	Add'l ** Fan KWH	ELECT. SAVINGS KWH	WASTE HT. AVAIL. BTU/LB	TOTAL WASTE HT. MMBTU	DOLLAR ** SAVINGS \$
												KWH					
102	2	112	1.00	113.78	87.39	41.27	33.07	7,257.33	34.78	87.0	174	189	0	15	26.39	0.38	2.04
97	104	107	0.94	112.55	87.14	39.72	34.62	6,516.46	33.55	75.4	7,840	8,508	0	668	25.41	17.22	91.61
92	296	102	0.88	111.33	86.87	38.19	36.15	5,842.32	32.33	65.1	19,278	20,889	0	1,612	24.46	42.30	223.99
87	407	97	0.82	110.11	86.57	36.67	37.67	5,224.32	31.11	56.0	22,808	24,700	169	1,722	23.54	50.05	258.76
82	618	92	0.76	108.88	86.25	35.17	39.17	4,656.62	29.88	48.0	29,649	33,665	494	3,522	22.63	65.12	380.24
77	776	87	0.70	107.66	85.91	33.67	40.67	4,130.81	28.66	40.8	31,677	38,935	789	6,468	21.75	69.72	498.81
72	1009	82	0.64	106.43	85.55	32.19	42.15	3,644.13	27.43	34.5	34,776	46,286	1168	10,342	20.88	76.77	658.74
67	747	77	0.58	105.21	85.16	30.72	43.62	3,191.20	26.21	28.8	21,543	31,055	937	8,574	20.05	47.80	482.71
62	642	72	0.52	103.98	84.77	29.27	45.07	2,769.03	24.98	23.9	15,312	23,929	851	7,765	19.21	34.15	400.62
57	601	67	0.46	102.76	84.35	27.82	46.52	2,373.17	23.76	19.4	11,685	19,816	830	7,301	18.41	26.26	353.26
52	684	62	0.40	101.53	83.93	26.39	47.95	2,002.09	22.53	15.6	10,638	19,611	975	7,998	17.60	24.10	368.34
47	569	60	0.34	100.31	83.76	25.81	48.53	1,681.43	21.31	12.4	7,030	13,867	595	6,242	16.55	15.83	275.57
42	667	60	0.28	100.31	83.76	25.81	48.53	1,384.71	21.31	10.2	6,786	13,386	460	6,140	16.55	15.29	269.90
37	621	60	0.22	100.31	83.76	25.81	48.53	1,087.99	21.31	8.0	4,964	9,793	309	4,520	16.55	11.18	198.39
32	504	60	0.16	100.31	83.76	25.81	48.53	791.26	21.31	5.8	2,930	5,780	191	2,659	16.55	6.60	116.81
27	229	60	0.10	100.31	83.76	25.81	48.53	494.54	21.31	3.6	832	1,641	68	741	16.55	1.87	32.69
22	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	16.55	0.00	0.00
17	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	16.55	0.00	0.00
12	0	60	0.00	100.31	83.76	25.81	48.53	0.00	21.31	0.0	0	0	0	0	16.55	0.00	0.00
8,476											227,924	312,050	7,836	76,290		504.66	\$4,612

* Motor efficiency of 85% assumed

** Additional Condensing fan power based on a fan motor size of 0.75 hp

*** Assumes a Boiler Efficiency of 80%